AUTOMATION

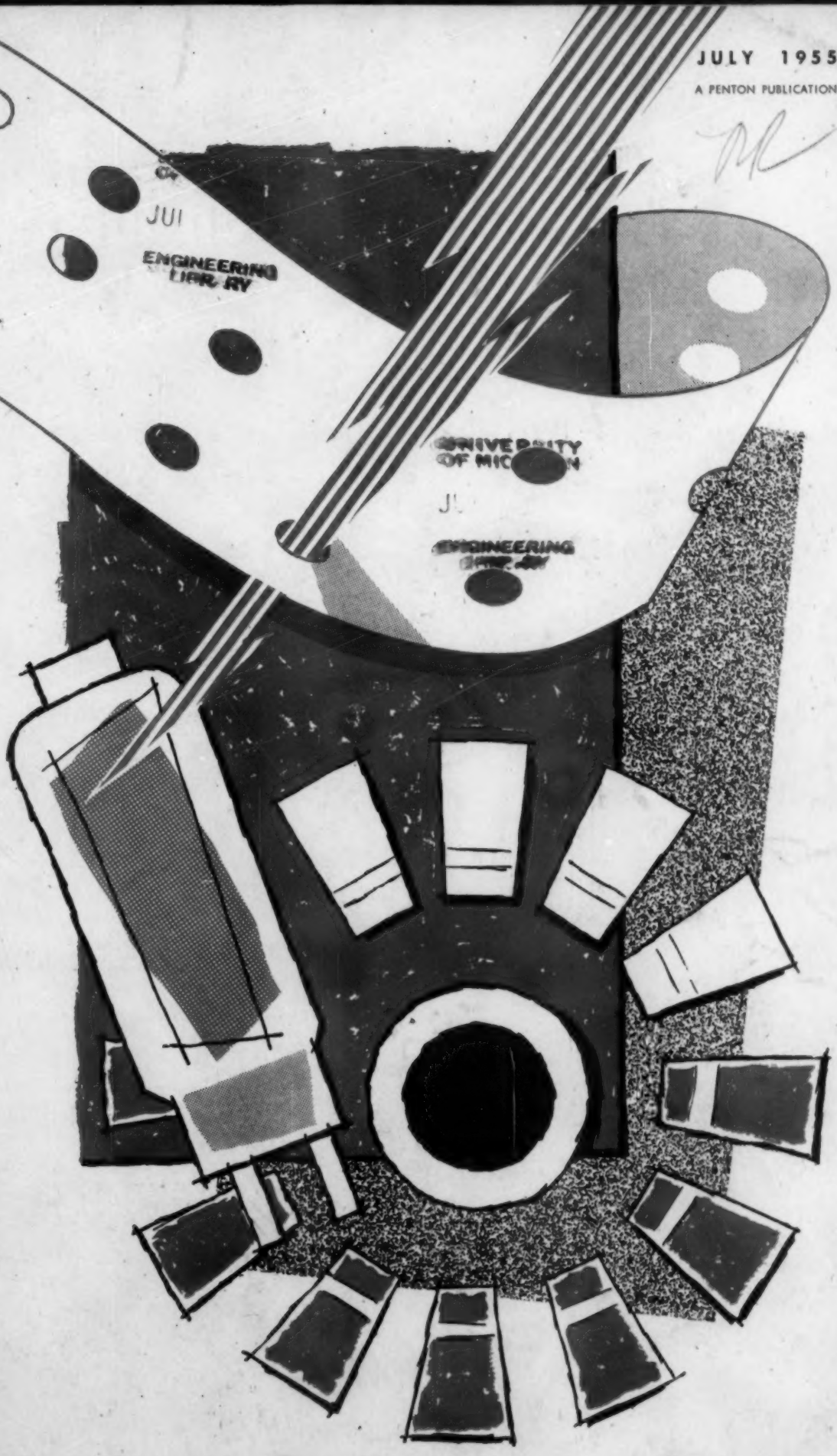
Registered U.S. Pat. Office

JULY 1955

A PENTON PUBLICATION

JUI

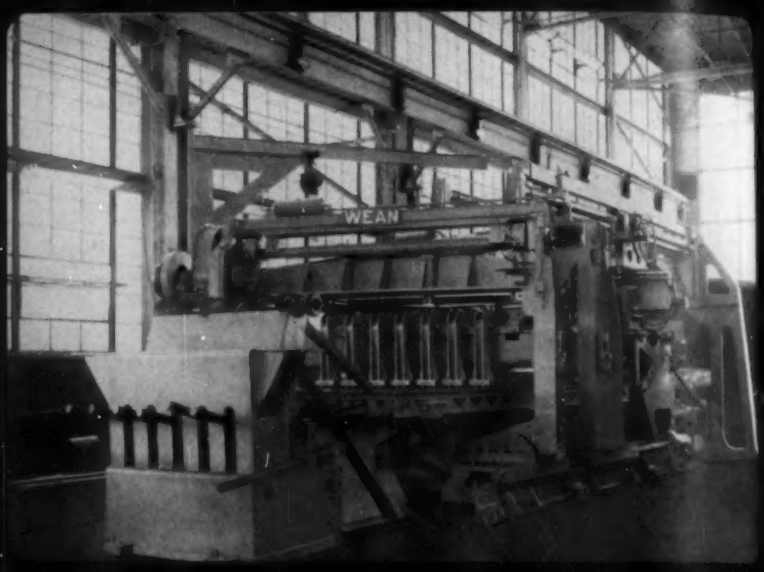
ENGINEERING
LIBRARY

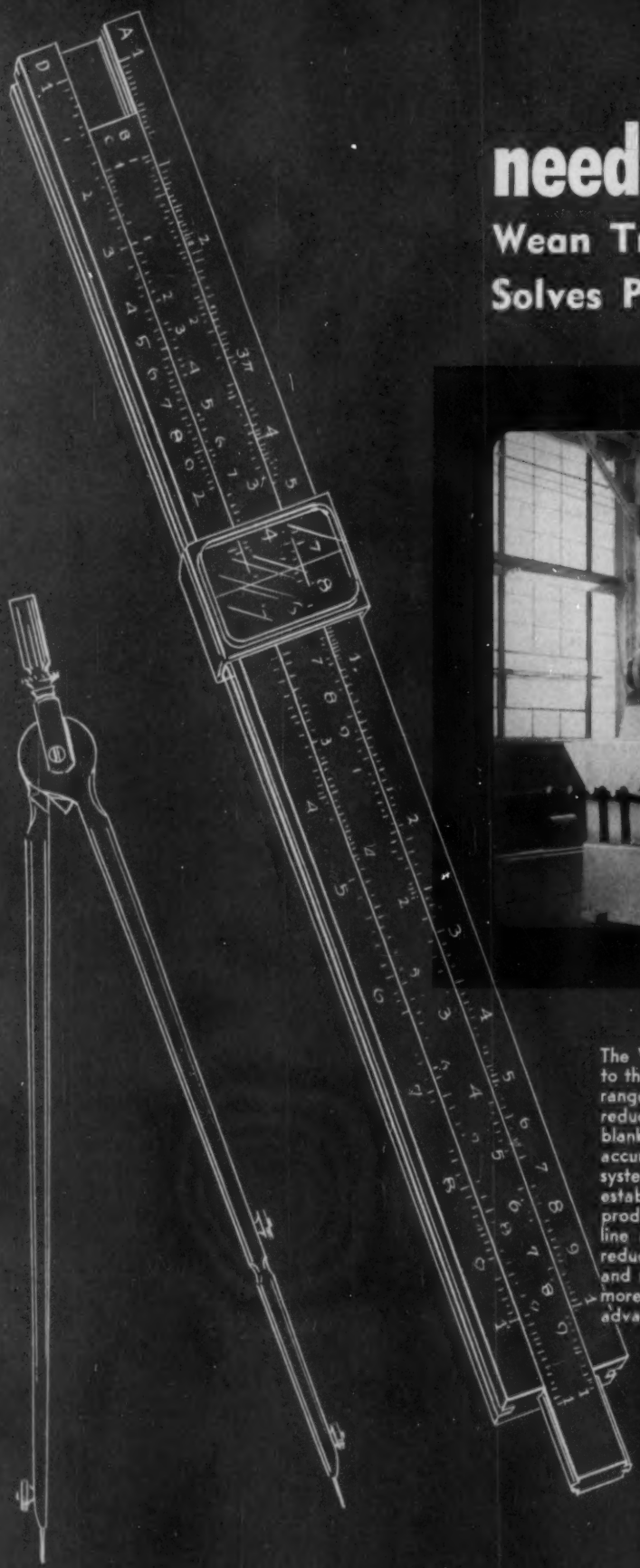


THE MAGAZINE OF AUTOMATIC OPERATIONS

need an idea?

Wean Trapezoidal Shear Line Solves Problem for Auto Maker





The Wean Trapezoidal Shear Line was developed as an answer to the high speed blanking of irregularly shaped pieces in the broad range that can be described as trapezoids or parallelograms. This use reduces tremendously the cost of expensive die setup in major blanking presses. Two pieces are made at each index with the accuracy that can only be achieved by a measured length indexing system. The cut can range from 45° to 90° angles. The latter setting establishes the line as a straight cut-up unit with twice the normal production of conventional shear lines. At Wean, we consider this line as another important step forward in our policy of cost reduction through progressive engineering. People in the automotive and metal fabricating fields have come to look more and more toward Wean Equipment for spectacular advances in machinery for metal processing.

Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

Offices:
CLEVELAND • DETROIT • CHICAGO • NEWARK, N.J.
Cable: WEANCOR

JULY, 1955
Vol. 2—No. 7

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

ROGER W. BOLZ, Editor

EDITORIAL STAFF

JAMES C. KEEBLER, Associate Editor
WILBUR R. ELLIS, Associate Editor
JOHN H. McRAINEY, Assistant Editor
LEE D. MILLER, Assistant Editor
FLEUR E. WOODS, Assistant Editor
HELEN M. VERESPY, Editorial Assistant

FLOYD G. LAWRENCE, Detroit Editor

EDWARD D. KARL, Art Editor

Editorial Representative

NORMAN LYNN
Los Angeles, Webster 5-3040

REGULAR DEPARTMENTS

Automation Outlook, 4
Automation News, 8
Detroit Dateline, 22
New Equipment, 78
New Components, 84
Patents, 92
New Literature, 94
Abstracts, 100
New Books, 108
Editorial Index, 110

Stabilizing Factor, 25
EDITORIAL—long range aspects of automation seen leveling out production and economic cycles.

Telemetering Speeds Weighing, 26
ROBERT B. ZILIUS—automated operations require improved weight measurement and transmission of weight data.

Producing Plastic Protection, 31
AUTOMATION TODAY—new installation manufactures and packages rolls of household wrapping material.

Versatile Automatic Nail Feeding, 35
CONTROL SYSTEM—electric programming of mechanical feeder on hydraulically actuated nail driving machine.

A Functional Morphology of Mechanisms, 37
E. W. LEAVER and J. J. BROWN—degrees of automatism classified by parameters of energy and information.

Statistical Control System of Inspection, 42
PACKAGE WEIGHING—equipment check weighs 100 per cent of production and interprets significance of off-limit items.

Automatic Cycling Cuts Manufacturing Costs, 46
LATHE OPERATION—twin mandrels on indexing turret permit loading and unloading motor frames while machine works.

Design for Automatic Assembly, 48
GEORGE H. KENDALL and JERRY A. HOST—part three—mechanisms and workpieces designed to minimize downtime.

Tying Paperwork to Production, 53
P. B. GARROTT—common language machine automatically embosses plate protecting factory data from error and mutilation.

Small Parts Handling, 57
E. A. CARNEY—automated plant receives large quantities of items for distribution to usage and storage points.

Basic Process Control, 60
C. W. WORLEY—part four—uses and characteristics of automatic controllers discussed in light of control utility.

Mechanized Shell Molding, 73
AUTOMATED FOUNDRY—improved form of mold production adapts to automatic machines and conveyorized handling.

automation outlook

MORE DEPENDENT ON HUMANS

". . . electronic data-processing machines are more dependent in some respects than existing standard office machines on human intervention to tell them what to do, less dependent on people to operate them. Groups of people, preferably with intimate knowledge of existing routines, will be needed to break down routines and procedures. Coding know-how can be acquired by a company's own staff members after a few weeks of specialized training. Duties of equipment operators will be no more difficult than those of good punched-card equipment operators. Machines will actually replace a majority of employees performing simple repetitive tasks, and open new jobs needing much creative thinking, initiative and responsibility, and offering higher pay . . ."—*J. Douglas Elliott, Detroit Edison.*

LONG, LONG AGO

". . . . idea of automatism probably dates back to the time when the first user of a hand tool wished that the tool would go on performing the work, leaving its owner free to go about more entertaining business. The development of automatism has taken place in orderly stages; it began with the primitive situation where man was forced to produce goods with his unaided hand . . . ."—*E. W. Leaver, president, Electronics Associates Ltd. and J. J. Brown, staff member, Aluminum Limited Group Co.* *See Page 37.*

ACCENT ON THE IRREPLACEABLE

". . . machinery has always replaced activities in which a human being was used in an inefficient manner. The galley slaves of antiquity were replaced by more powerful and more efficient ways of propelling ships simply because the use of a human being for his muscle power is a wasteful and inefficient employment of a very delicate mechanism, looked at in the most materialistic terms. It is no less a waste of human energy to have people count or take stock of inventory or post figures in books and perform the myriad other clerical activities which require no real thought, and which are drudgery. These will be increasingly replaced by machines, while the *creative* thought process can never be so replaced . . ." —*John H. Troll, vice president for engineering, Electronics Corporation of America.*

NEW TREND IN ENGINEERING EDUCATION

". . . as a result of automation, the technologist, physicist and engineer are moving into a phase where their work will become even more useful and creative. It's going to leave us professionally on a much higher plane, doing a type of intellectual work which has not yet been appreciated in educational and collegiate circles. It is my firm belief that the automatic and electronic age will introduce creative and imaginative qualities never before within the sphere of organization and institutional activities. A better appreciation of training within industry coupled with this new age will make for developments within the next fifty years which should make those of the last fifty seem inconsequential . . ."—*Dr. Allen R. Cullimore, president emeritus, Newark College of Engineering.*

CHALLENGE TO INDUSTRY

". . . afraid of borrowing trouble, industry has been slow with its word on automation, far too slow. Now we find ourselves in the rather ridiculous position of having to defend a manufacturing technique that is not only logical but absolutely essential to the growth and well being of our country. Labor has argued that industry has shrugged its responsibility as Americans by allowing automation to grow. The only responsibility that industry has shrugged is that of communicating to the people what automation is and what its effects will be. This is your challenge, and the challenge of every segment of industry that is at all connected with the growth of automation: to use every means at your disposal to make evident to the American people what automation is, how it has come about, and what it will result in . . ."—*D. C. Burnham, vice president-manufacturing, Westinghouse Electric Corp.*

AUTOMATION

Penton Building, Cleveland 13, Ohio
Main 1-8260

EDWARD S. LAWSON
Business Manager

BUSINESS STAFF

Elizabeth Root, *Advertising Service Manager*

J. M. Castiglione, *Production Manager*

D. C. Kiefer, *Marketing Director*

June Schilens, *Reprints*

Advertising Representatives

New York 17 ..... 60 East 42nd St.
Fred A. Stanley
Murray Hill 2-2581

Cleveland 13 ..... Penton Building
Larry D. Brennan
Main 1-8260

Chicago 11 ..... 520 North Michigan Ave.
Richard K. Lotz
Richard W. Jones
Whitehall 4-1234

Los Angeles 57 ..... 2330 West Third St.
The Robert W. Walker Co.
Dunkirk 7-4388

San Francisco 4 ..... 57 Post St.
The Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. ..... 331 South Twelfth St.
Fred J. Allen
Griffin 7854

Circulation

Jack C. Gernhard, *Manager*

Amy Lombardo, *Directory & List Dept.*

Published by

THE PENTON PUBLISHING COMPANY

G. O. HAYS ..... *President and Treasurer*
R. C. JAENKE ..... *Executive Vice President*
F. G. STEINEBACH ..... *Vice Pres. and Secretary*
F. O. RICE ..... *Vice President*
J. P. LIPKA ..... *Asst. Secy. and Asst. Treas.*

Also Publisher of
STEEL • FOUNDRY • MACHINE DESIGN
NEW EQUIPMENT DIGEST

Published monthly. Subscription in the United States, possessions, and Canada: One year $10. Single copies, $1.00. Other countries one year, $20.

Copyright 1955 by The Penton Publishing Company.
Accepted as Controlled Circulation Publication at Cleveland, Ohio.

BPA

An exposition that does something about AUTOMATION. In one place at one time you can *see* the practical things—mechanisms, instruments, controls, handling devices, data processors, hydraulic, electric, mechanical, and pneumatic components—that you can apply *right now* to make your production and processing more automatic.

There's no blue sky about this show. It's been designed for the production function in industry, leveled at the men who must re-engineer production and processing lines *now* to cope with rising costs and hot competition.

There'll be hundreds of exhibits by leading companies. There'll be thousands of technical experts eager to show you how to get more output from your existing plant facilities.

AUTOMATION is here. Today. The things you learn at the Production Engineering Show can go to work for you immediately to cut costs, to improve production performance.

You can see the great MACHINE TOOL SHOW too!

Your registration badge will admit you, at no additional fee, to the world-important Machine Tool Show – the first since 1947 – at the International Amphitheatre, Chicago, concurrent with the Production Engineering Show. Don't miss it! Shuttle buses will run between shows.

See the practical elements of automation that can be applied to your production and processing right now!

PRODUCTION ENGINEERING SHOW

SEPTEMBER 6-16, 1955
NAVY PIER, CHICAGO

The Automation Exposition

Tickets:
To expedite your registration at the Production Engineering Show, write for Rapid Registration Cards to:

Clapp & Poliak, Inc.
Exposition Management, Dept. PES-1,
341 Madison Avenue, New York 17, N. Y.

AUTOMATION news

Today's events and developments in the field of automation

It Takes Automation To Supply Automation

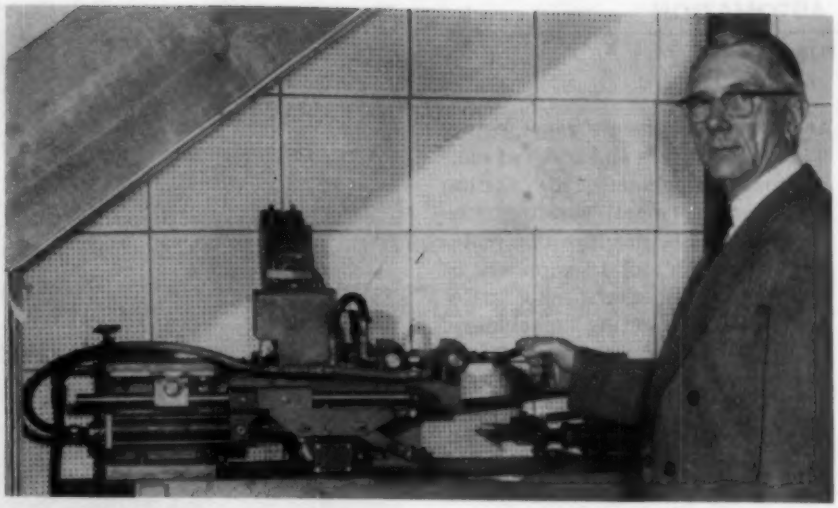
USED for years by the metalworking industries as cutting tools, cemented carbides have been adopted by International Business Machines Corp. to cut processing costs and to overcome certain maintenance problems arising from the corrosive action of the inks the company uses in printing the millions of cards it needs for its highly-mechanized electrical tabulating and accounting machines. An indication of how carbides helped to reduce card production costs can be gained from the company's shearing operation in trimming cards to proper sizes. Formerly, the steel knives employed at a shearing rate of 1600 cards per minute, sliced off about 16 million cards before knife sharpening was required. With the application of Carboloy carbide knives, running at the same rate per minute, IBM trims about 267 million cards before resharpening is required.

ROLLED card stock is fed through special automatic machine at International Business Machines Corp. plant in production of tabulating cards. Each machine prints, straightens, shears, clips, inspects, counts and stacks cards at rate of 1600 per minute. Tolerance on length of card is held to plus or minus 0.0035-inches in this production operation.

Card production at IBM is virtually a picture of automation, involving considerable volume to keep the many machines now in use by business fully supplied. The cards are printed, straightened, sheared, clipped, inspected, counted and stacked automatically by a battery of machines. Each tabulating card produced by IBM measures precisely 3.246 x 7.375 inches, and only 0.007-inch thick. Card dimensions are extremely critical. The tolerance on the length, for example, is held to plus or minus 0.0035-inches. Each card machine employed is a self-contained production unit. From rolled card stock to the completed, counted card, all operations are automatic. Each machine includes a built-in miniature printing press, which prints lines, figures etc., on the card stock before each card is cut to size. Ink supply for the printing press is fed from a well located in the base of the machine. To overcome the corrosive action of the ink, company engineers installed impeller bushings and shafts of Carboloy grade 44A carbide in the stainless steel submerged pumps which meter the ink to the printing press of each machine. After being printed, the cards are sheared to length by solid carbide rotary shear knives at the rate of 1600 per minute. The knives, of Carboloy grade 55A carbide, are fabricated for IBM by U. S. Carbide Tool Co.

Following the shearing operation, the cards are then mechan-

ically inserted into slots in the rim of a rapidly revolving drum located on top of each machine. After traveling around the rim or drum of each machine, another cutting operation involving carbide knives is performed. This consists of making a cut of 45 degrees off the righthand corner of each card by a pair of carbide knives operating at 1600 strokes per minute. The manufacturing cycle is finished when completed cards are ejected from the rim slots following the corner cut. The cards are then boxed and placed on conveyors for shipment to users.



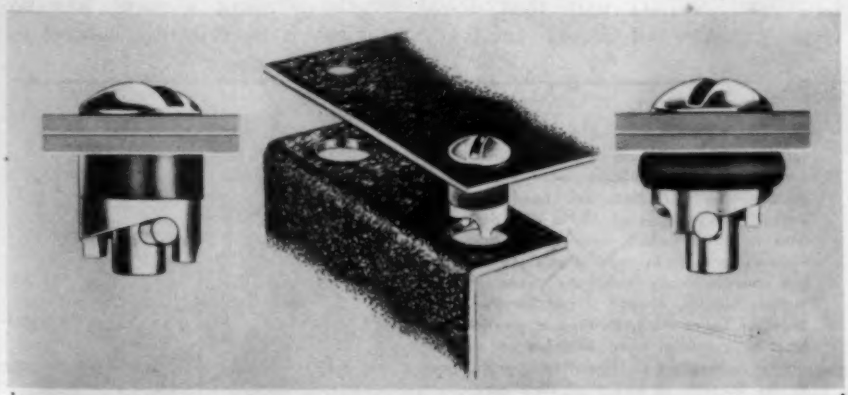
IN AN ENDURANCE TEST performed on a specially designed testing machine, a new jaw assembly for the Sahlin Iron Hand press unloader has successfully completed more than one million gripping and removing cycles, reports its inventor, Henry Sahlin, founder of Sahlin Engineering Co. Inc. In addition to this jaw, ten other types of jaws to handle specialized press unloading problems have been developed. The jaws are tested in the machine, which can be adjusted to simulate actual operating conditions.

ACQUIREMENT of Varady Engineering Div. by Wheeler Associates Inc. has been announced by **William S. Wheeler,** president. Ac-

quistion represents part of Wheeler Associates expansion program in developing facilities to offer completely rounded out engineering services to industry and the military. Varady has in the last ten years served many clients in the design of such items as coal handling and processing plants, industrial buildings, steel tube manufacturing equipment and machinery, tools, dies and fixtures and infrared ovens.

Washing With Soundwaves

NEW washing device that uses soundwaves rather than physical agitation to press soapy water through clothes has been invented by G. Developments Ltd. of London. Known as the Gnome Vibrator, the machine is electrically operated. It produces 6000 vibrations a minute, which effectively dissolve and remove dirt without moving the clothes. Lace, wool and other so-called unlaunderable fabrics thus emerge unharmed. It is virtually noiseless. At present the vibrator is made in a single small, inexpensive size suited to a private home or apartment. The unit is not a washing machine in the ordinary sense. It resembles a huge spinning top in shape, and may be used in a variety of vessels—sink, basin, washtub, etc.—and for a number of different purposes. Already it has proved its usefulness as a perfume-mixer, and in the tanning and auto industries.



FASTENER which is a half-turn panel-to-base unit that combines the functions of a positive lock with those of an elastic shock mount and vibration isolator has been developed by the Vibrex Fastener Corp. The multifunction fastener floats the entire panel in live, resilient rubber and smothers rattles and noise and isolates vibration and shock. It compensates for misalignment between panel and base and is water, dust and pressure proof. The new device is ideal for fastening problems involving sheet metal, plastics, breakable and brittle materials such as glass and ceramic.

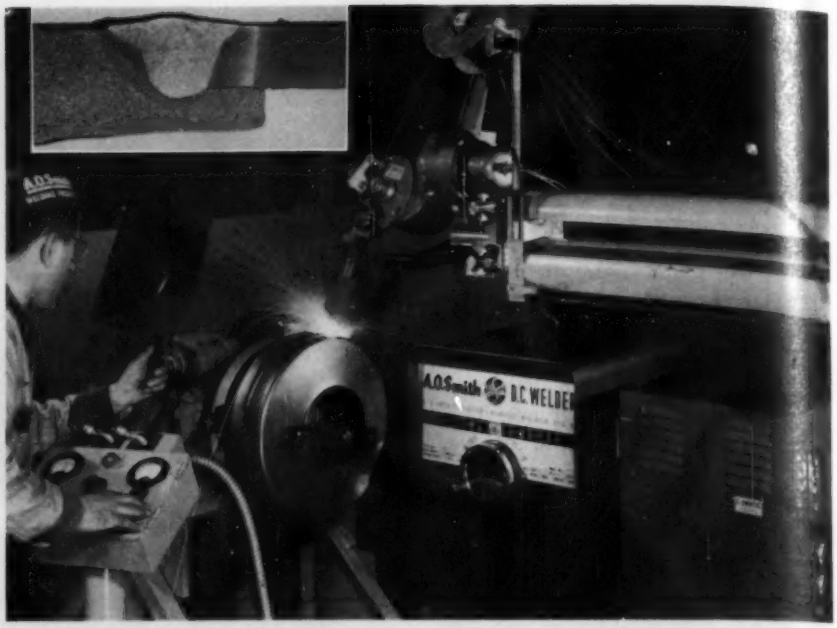
Standardization Talks Indicate Importance of Hydraulics

DISCUSSIONS of standardization of hydraulic components, a new type of fire resistant fluids and how to design and build for leakproof connections in hydraulically actuated equipment highlighted the Fabricating Machinery Hydraulic Conference sponsored by Vickers Inc. The conference was attended by nearly 150 design, maintenance

and service engineers representing 88 manufacturers and users of metalforming machinery, die casting equipment, presses, welding machinery and plastics injection molding equipment and 15 suppliers of hydraulic components and materials for fabricating machinery. Keynote speaker was **D. J. Davis,** vice president Ford Motor Co., who discussed the increasingly important role being played by hydraulics in industry. Co-moderators for the two-day meeting were **Royal E. Russell,** master mechanic, Chrysler Corp., and **Adolphe J. de Matteo,** chief engineer, Watson-Stillman Co. Div. of H. K. Porter Co. Inc.

In the discussion on standardization of hydraulic components for fabricating machinery, the need for interchangeability with regard to size and location of ports as well as mounting pad configurations and dimensions was brought out. It was noted that while no large-scale trend toward standardization is currently in evidence, the subject is being given serious consideration by suppliers.

NEW firm has been formed which will specialize in the engineering of special automation equipment. Press Automation Systems Inc. is to be headed by **Maurice M. Clemons.** For the past year, Clemons has been chief engineer of Sahlin Engineering Co. Inc., manufacturers of the "Iron Hand." Prior to that time, he was associated with General Motors for 25 years. New company will also serve as national sales outlet for feeders, unloaders and special machinery manufactured by Hamilton Automation Co. **Jack Young,** president of Hamilton will be vice president and director of Press Automation Systems.

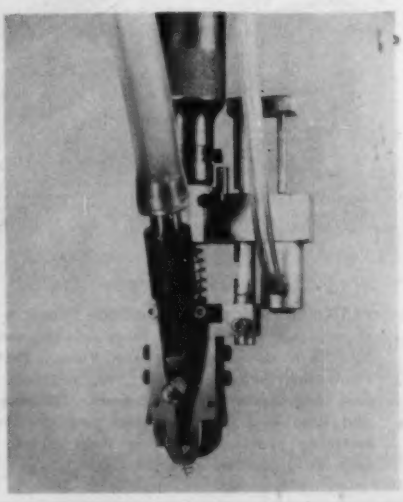


AUTOMATIC welding process which uses low-cost carbon dioxide gas for shielding the arc while welding mild and medium carbon steel has been developed by the A. O. Smith Corp. Impressive savings in cost of gas can be realized by use of carbon dioxide. X-ray quality welds can be obtained with the new C-OMATIC process using 30 cu ft (or less) of carbon dioxide per hour. Welds using carbon dioxide have a wide and well rounded bead penetration. Unit is convertible to submerged arc process with nozzle substitution and minor electrical connection changes.

Versatile Liquid Detector

LIQUID-SENSING unit that detects presence of liquid in 0.4 seconds and absence of liquid in five seconds is being manufactured by Air Associates Inc. Complete unit consists of an electrically powered probe containing a tiny thermistor, a compact power-control package, and an interconnecting cable. Control unit can be obtained in either explosion-proof or vapor-proof models. Multiple probe types are available for automation applications in which several chain operations are required to be automatic. Inasmuch as the sensing element has no moving parts, it is not subject to

COMPLETE automation of screw fastening is possible with use of device manufactured by Pneuma-Serve Inc. Speed of fastening operations has been improved over ranges of 50 to 400 per cent in plants which have tested the Pneuma-Serve. In operation, screws are pneumatically conveyed from a hopper holding enough screws for five to eight hours work, through a plastic hose to a special head mounted on a power screwdriver. The head grips screws in such a way that they may be driven at any angle in any plane. After one screw has been driven, the next is automatically fed and instantly positioned. The operator may take the driver and head assembly to work stations located as far as 20 feet from the hopper. Screws up to ¼-inch in diameter and 1¼-inches in length may be handled by the device.



New Westinghouse control relays

for pilot circuits, automatic control and sequencing operations

Specially designed friction-free bearings—exclusive with Westinghouse—eliminate sticking or jamming and sliding wear. That's why the new Westinghouse control relays are *always* dependable—stay on the job longer.

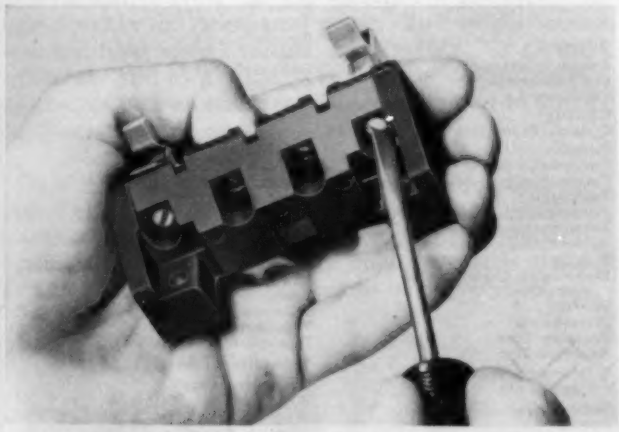
Designed particularly for any circuits involving rapid openings and closings. Positive action, kick-out spring provides rapid, dependable operation.

Rated at 10 amperes (open). Available in any combination of normally open or normally closed contacts; 2, 3, 4 or 6 pole for any voltage up to 600 volts a-c; and either open or in standard NEMA enclosures for specific applications.

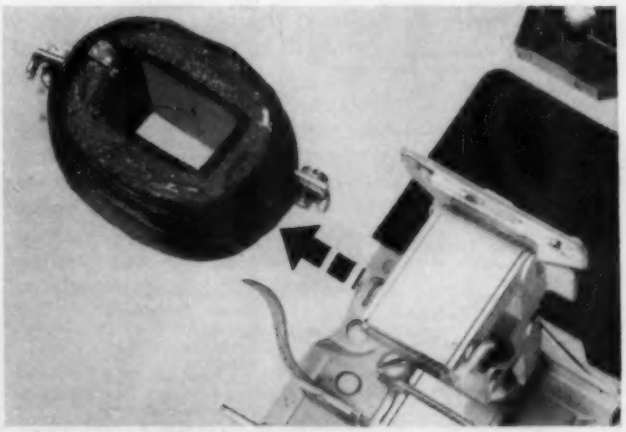
For *all* the facts, call the control sales engineer at your nearest Westinghouse office, *The Man With The Facts!* J-30187

YOU CAN BE SURE...IF IT'S

Westinghouse



Easier Contact Changes . . . Switch from normally open position to normally closed position, or vice versa, easily made in the field. All you need is a standard screw driver—there are no parts to add or any wires to disconnect.



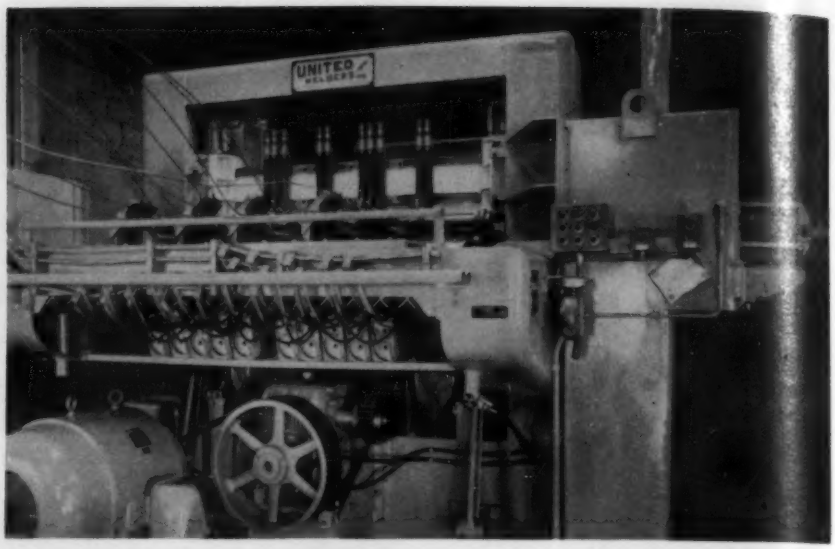
Easily Accessible Parts . . . Removing the magnet coil from the relay is quickly accomplished as evidenced by the above photograph of the magnet coil and retaining spring. All other parts are equally accessible—easy to get at.

wear, clogging, corrosion, vibration or shock. No electrical contact is made with the liquid.

The unit will operate in a liquid temperature range of minus 319F to plus 200F and can be applied to almost any type of liquid system.

SAMA Annual Meeting

NEWLY elected president of the Scientific Apparatus Makers Association is **Henry F. Dever,** president of Brown Instruments Div., Minneapolis - Honeywell Regulator Co. Dever joined Honeywell in 1931 and prior to his appointment to his present position in 1946, was vice president in charge of engineering in Minneapolis. He is also a member of the American Society of Heating and Air Conditioning Engineers, the Franklin Institute and the Newcomen Society.



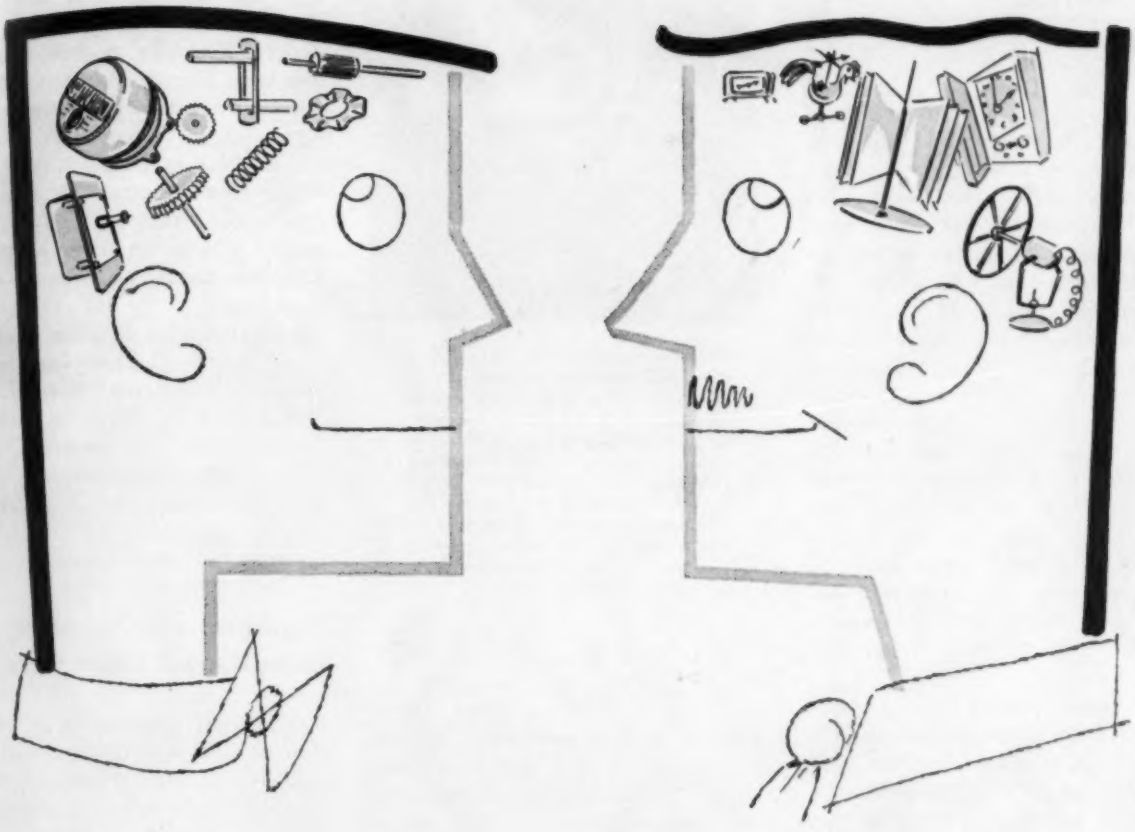
WIRE MATTING used in automobile seats is formed and welded automatically by this machine built by United Welders Inc. Sixteen strands of wire are fed from coiled stock into front of machine and single strand from right side to form the matting. All moving parts of the machine are driven by 50 hp motor through Michigan Tool Co. Cone-Drive speed reducer.

Among the papers presented at the 37th annual meeting of SAMA was a discussion of the guaranteed annual wage by **Dr. George W. Taylor,** professor of Industry,

TESTS USED IN PAPER INDUSTRY

Abrasion Resistance
Absorbency
Absorptive Capacity
Absorptivity
Acidity
Alkali Resistance
Alkali-Staining Resistance
Anti-tarnish Test
Arsenic
Ash*
Bacteriological*
Basis Weight
Bleeding Resistance
Blocking Resistance
Bonding Strength
Brightness
Bulk*
Bursting Strength
Caliper
Casein*
Cellulose
Chemical Analysis
Chlorides
Coated Paper
Coating Agents*
Color
Compressibility
Color Matching
Conditioning
Copper
Copper Number
Creasing Quality
Crushing Strength
Curl
Dielectric Properties
Dimensions
Dimensional Stability
Dirt*
Dirt Content*
Elasticity
Electrical Properties
Erasing Quality*
Fastness to Light
Fibers*
Fillers
Filter Paper
Flammability
Fluorescence Analysis
Folding Endurance
Formation
Furnish
Fuzz
Gelatin
Gloss
Glue*
Greaseproofness
Grease Resistance*
Handle
Hardness
Humidity
Humidity, effect of
Hydrogen ion Concentration
Hygroexpansivity
Impact Test
Impregnating Materials
Insect Resistance*
Iron
Light Fastness
Machine Direction
Mechanical Pulp
Mercury
Microbiology
Microscopy*
Moisture
Nitrogen
Odors—transmission*
Oil Penetration
Oil Resistance
Opacity*
Optical Properties*
Paraffin
Parchment paper—pentosan*
Parchment paper—permanence
Pentosans*
Permeability—gases
Permeability—water
Permeability—water vapor
Pick Test
Pinholes in glassine and greaseproof
Porosity
Printability
Prussian Blue
Puncture Test
Quaternary Ammonium Compounds
Reflectance
Resins
Rosin*
Rosin Size*
Rubber
Sampling
Scuff Resistance
Sectioning
Silver Tarnish Test
Size Resistance
Slip Test
Smoothness
Speck Count
Specks
Starch*
Stiffness*
Strength*
Stress-Strain Relation
Stretch
Sulphates
Sulphur
Surface
Surface Area
Synthetic Resins
Tannins
Tearing Strength
Tensile Strength
Thermal Conductivity
Thickness*
Titanium Dioxide*
Titanium Pigments*
Transparency
Transparent Materials
Vulcanized Fibers
Waterproofness*
Water-soluble Matter
Wearing Qualities
Wet-rub Resistance
Wet Strength
Wettability*
Wire and Felt Sides
Wool
Young's Modulus
Zinc

TESTING division of the Technical Association of the Pulp and Paper Industry believes that many of the instruments employed in other industries can be adapted to fill the needs of the paper industry. Sixth Testing Conference to be held in Springfield, Mass., Sept. 28-30 will feature an exhibition of testing instruments in order to effect an exchange of information by users and all types of instrument manufacturers. Above list specifies many items being tested and properties being tested for in the paper industry today. Asterisks indicate some of areas of main concern to TAPPI members.



... it is in the product development stage when SYNCHRON engineers can serve you best

You are designing a machine to control a predetermined cycle of operation, or to accomplish some desired motion. To do the job effectively you need a timing motor of adequate power and dependable accuracy. Size, speed, torque, adaptability . . . all are important. And to get the best possible performance, your motor and machine must be engineered to work together, smoothly and efficiently.

Over the years, it has been our observation that the most successful timing devices have been the result of co-ordinated engineering between the machine designer and SYNCHRON motor engineers. It is a simple case of "you tell us" what is to be expected of our motors . . . the power required, the general nature of the job it is to do, the proposed method of mounting, whether the action of the machine is continuous or interrupted . . . and any peculiarities of performance that may be demanded of it.

Do this . . . and let our engineers submit their suggestions along with a sample motor. We may save you many costly manhours of research and test time. This service is free to any established organization of sound reputation and reliable rating. We suggest you contact your local SYNCHRON Representative, or address the factory. All development engineering is conducted in strictest confidence.

FACTORY REPRESENTATIVES

Wesley Fromm, 5254 W. Madison St., Chicago, Ill.
R. H. Winslow & Associates, 123 E. 37th St., New York, N. Y.
Electric Motor Engineering, Inc., 8255 Beverly Blvd., Los Angeles, Cal.

"Workhorse of the Industry"

SYNCHRON SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, AND MAGNA-TORC D.C. MOTORS

HANSEN MANUFACTURING CO., INC. PRINCETON 10, INDIANA

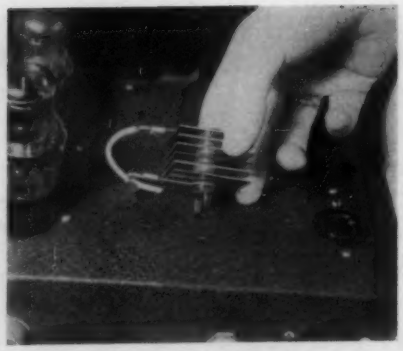
Established 1907

Wharton School, University of Pennsylvania. He said in part, "Also closely allied to the union's demand for the guaranteed annual wage is the risk of layoff because of so-called automation or technological change as well as because of plant relocation. It is reasoned that a requirement to pay wages to laid-off employees will induce employers to introduce labor-saving devices when total demand for labor is increasing and to build new plants in established localities. In these particulars, as well as respects regularization of production, the union seeks indirectly to influence certain managerial decisions, though not to participate directly in their determination.

"In essence, then, the demand for the guaranteed annual wage—and it is emphasized that the term is something of a misnomer—is a proposed additional program for placing greater responsibility upon the employer for minimizing certain kinds of unemployment.

"The current wage demand is thus related to a whole series of efforts to deal with unemployment. It focuses attention upon three aspects of the problem. In the first place, it is urged that laid-off workers should be accorded the right to receive, for a time, unemployment benefits sufficient to enable them to maintain their customary standard of living. Employers are being asked to provide for the right to the extent the governmental system falls short. Secondly, a new emphasis has been placed upon the need for better production planning through changes in inventory policies, where that is possible, and by a better co-ordination of sales and production policies. The third aspect relates to those employees who lose their jobs because of automation.

"What can be done, or should be done, by employers and by the various industries, however, depends upon the facts of each particular case. A program which may be adopted under one cannot be a 'pattern' type of determination of the issue which is called guaranteed annual wage."



SNAP-IN type rectifier featuring a clip arrangement which does not require tools for assembly, speeds assembly time and eliminates broken studs, has been developed by the Radio Receptor Co. Inc. The new device was developed in conjunction with the Tinnerman Products Corp., manufacturers of speed-type fasteners. Unit does not require special sockets for mounting, needing only two round holes to be snapped into place

SCHOOL of Engineering participated in Michigan State College Centennial Symposium by sponsoring program devoted to "Automation—Engineering for Tomorrow". R. W. Bolz, AUTOMATION, speaking on "Automation to Date" delivered the keynote address at the general session. Other speakers included J. B. Cunningham, automation consultant and Dr. W. R. G. Baker, vice president, General Electric Co. Prior to this, Bolz also presented a talk on production processes and automation to graduate students at Wisconsin University. Among other events associated with the Wisconsin trip was the opportunity to review automation developments at Gisholt Machine Co. with Ed Helmke (left), assistant chief engineer.

Duplicates and Transmits Using Normal Typewriters

RECEIVER typewriter in production offices, warehouses and shipping points can be connected to a master typewriter in a central office over standard telephone cables. Development of the American Automatic Typewriter Co. utilizes any standard keyboard electric typewriter to achieve instantaneous duplication of orders in intra - office installations. Chances of error are limited to one central point and use of standard keyboard simplifies training requirements. Simple electrical circuits can be serviced by any electrician; typewriter service can be provided by regular typewriter service organization.

Project Tinkertoy Changes Hands

NAVY Bureau of Aeronautics and the National Bureau of Standards have announced that the NBS pilot line for the mechanized production of electronic equipment will be operated by Aerovox Corp., manufacturers of electronic components. Aerovox succeeds the Kaiser Electronics Div. of Willys Motors Inc. in the operation of the line, which produces electronic products based on a unique system of electronic modular design —formerly code-named Project Tinkertoy. The arrangement with Aerovox is designed to broaden

Power aplenty 'til the pond ran dry

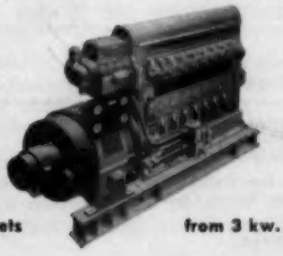
That was the complaint in the days of water-wheel power—and still is today.

In every season, water shortages force large areas to curtail power usage . . . storms tear up vast power networks . . . solid fuel shortages bring with them power rationing.

In many cases, a single power failure can cost you more than the installed price of a dependable Fairbanks-Morse Diesel Generating Set! In addition, there are day-to-day savings with in-plant power: eliminate power factor penalties, add to current capacity as load increases, reduce peak demand values for lower purchased power rates, and often lower insurance rates.

We'll gladly send you more information or survey your plant's power requirements without obligation. Why not find out about In-Plant power generation today—*before* power fails you?

Fairbanks, Morse & Co., Chicago 5, Ill.



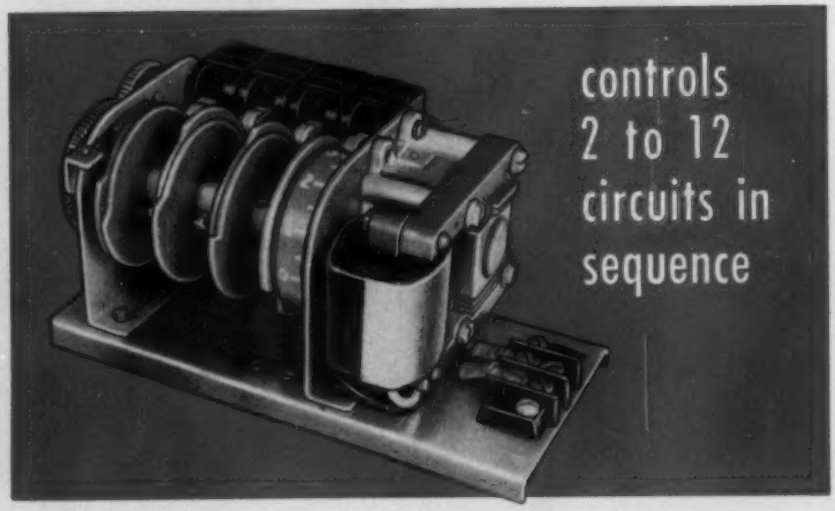
F. M. Diesel Generating sets from 3 kw. to 1700 kw. capacity

FAIRBANKS-MORSE

a name worth remembering when you want the best

DIESEL AND DUAL FUEL ENGINES • DIESEL LOCOMOTIVES • RAIL CARS • ELECTRICAL MACHINERY • PUMPS • SCALES • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

EAGLE MULTIPULSE repeat cycle timer



2" diameter cams adjustable within ½%

This compact Timer features in its construction an "Expandex" hub— an Eagle Signal exclusive. Hub can be loosened or tightened until there's just enough friction between it and the cam shaft to allow moving the cam a hair thickness distance . . . as little as ½% of one revolution. Close settings are further facilitated since the "Expandex" hub eliminates shaft indentations caused by set screws. There is no occasion for a set screw to slip into a previous indentation.

Opening or closing as many as 12 circuits in sequence, the Eagle Multipulse Repeat Cycle Timer is ideal for sequence starting of several motors, timed sequencing of automatic cement block machines, and sequence operation of solenoid valves in washing processes.

Cycle change gears provide 3 to 1 time range. Available with 2 to 12 circuits . . . and with time cycles from 18 seconds to 36. hours. Synchronous motor powered. S.P.D.T. enclosed contacts. Available with cams factory set if desired. Send for free Bulletin 323.

MAIL COUPON TODAY

EAGLE SIGNAL CORPORATION
Industrial Division
MOLINE, ILLINOIS

Eagle timers save time . . . save money

EAGLE SIGNAL CORPORATION
Industrial Division, Dept. A-55
MOLINE, ILLINOIS

Please send free Bulletin 323 containing full data on Multipulse Repeat Cycle Timer.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

the nation's industrial base in experience and know-how for the use for modular design concepts in military equipment. Key personnel, formerly associated with the Kaiser Electronics Div. have been employed by Aerovox to take advantage of their experience in modular design concepts and in the operation of the mechanized production facility. To encourage the maximum use of this advanced concept of modular design in a wide variety of military equipment, emphasis will be placed on the production of modules for experimental use by interested electronic equipment manufacturers.

MEETINGS AND EVENTS

July 12-14—

Western Plant Maintenance & Engineering Show. To be held Pan Pacific Auditorium, Los Angeles. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Aug. 15-17—

Society of Automotive Engineers. Golden Anniversary West Coast meeting. To be held Hotel Multnomah, Portland, Oregon. Additional information may be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Aug. 22-23—

National Industrial Conference Board. Electronic and automation symposium, jointly sponsored by Stanford Research Institute, to be held San Francisco. Additional information may be obtained from NICB headquarters, 247 Park Ave., New York, N. Y.

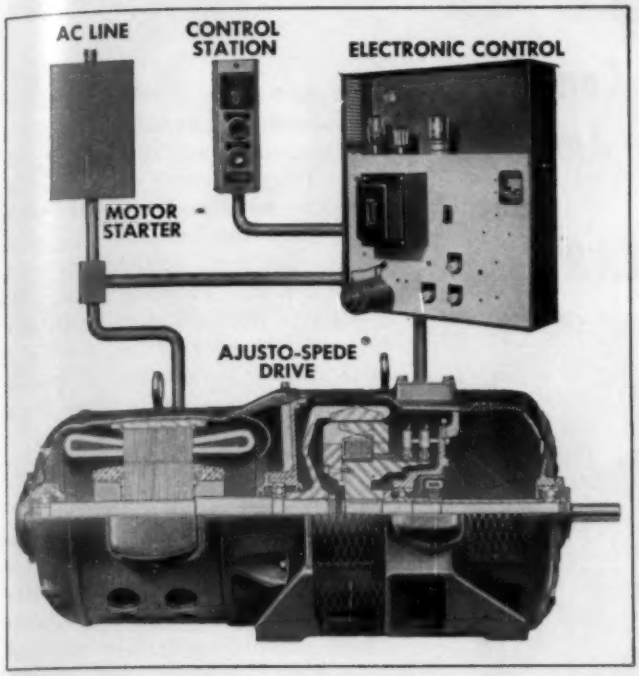
Aug. 24-26—

Western Electronic Show and Convention. To be held Civic Auditorium, San Francisco. Additional information may be obtained from Mal Mobley Jr., Business Manager, 344 North La Brea Ave., Los Angeles 36, Calif.

Sept. 6-16—

National Machine Tool Builders Association. Machine Tool Show

SPEED CONTROL BY



DYNAMATIC®

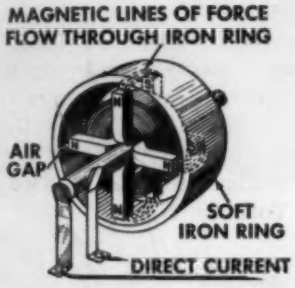
How it Works — What it Does — Why it's Better

Increased production, reduced costs, improved quality of product, and more complex processing techniques demand an ever increasing use of stepless adjustable speed drives. Dynamatic eddy-current equipment in one form or another attains these objectives.

Dynamatic Ajusto-Spede® Drives, Air and Liquid Cooled Couplings, Air and Liquid Cooled Brakes, Absorption, Motoring, and Universal Dynamometers operate on the same basic electro-magnetic principle.

A typical installation pictorially illustrates the simplicity and minimum components required to obtain controlled adjustable speed.

Basic Principles of Operation



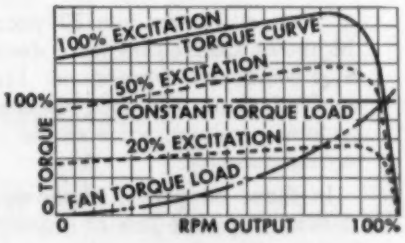
The transmitting of torque by Dynamatic eddy-current devices is based upon a simple magnetic principle easily demonstrated by the physics experiment, using a horseshoe magnet, iron filings, and a piece of cardboard. If several unmagnetized soft iron bars in the shape of a U, illustrated in the above drawing, are inserted in an insulated coil of wire, the bars will become magnets when direct current flows through the coil. Strength of the magnetic field is determined by the current flowing and the number of turns in the coil. By adding a solid ring of soft iron, encircling the poles of the electromagnets, the magnetic lines of force will flow through the ring. The basic construction of all Dynamatic eddy-current rotating equipment is then simulated.

The illustration shows magnetic lines of force with no relative rotation between the ring and magnets. When the field assembly (magnets and coil) is rotated mechanically, the iron ring separated from it by a nominal air gap remains stationary until current is applied to the coil. With the coil energized, mechanical rotation of the magnets produces movement of magnetic flux in the ring, creating eddy-currents in the ring. These induced currents develop a second magnetic field. Its strength is determined by the strength of the primary field and the relative speed difference (slip) between the two members. In the eddy-current coupling, attraction of these two fields cause the ring to follow the field magnets in rotation. When the coil current is varied, the eddy-currents will be proportionately affected, and torque produced at the output shaft will be similarly changed.

A typical eddy-current coupling torque curve with rated excitation and additional curves with reduced excitation is shown. In the same figure, a constant torque and fan torque load curve is plotted. Excess torque, which is a measure of accelerating capacity, is indicated. The Dynamatic coupling transmits this torque from a driving member, that may be either the drum ring or field magnets, to a driven member without mechanical contact.

Because of the extremely small excitation requirements, Dynamatic units lend themselves readily to electronic or magnetic amplifier control.

By taking advantage of the very high amplification factor of these controls, the largest couplings can be easily and conveniently controlled with a small adjusting potentiometer. The voltage output of a permanent magnet alternator mounted on the coupling output shaft varies directly with the shaft speed. This variable voltage signal modulates the control, automatically maintaining the selected speed of the coupling output shaft, within close limits, over a wide speed range.



Other features are easily incorporated—constant tension, controlled acceleration, threading, jogging or inching, torque limit, speed matching, and many others.

The relative simplicity, smoothness of operation, accuracy, ease of control and low maintenance of Dynamatic eddy-current equipment are factors meriting serious consideration of this type of equipment on almost all adjustable speed applications.

A free copy of the Dynamatic General Bulletin describing eddy-current equipment in more detail is available. Write for your copy.

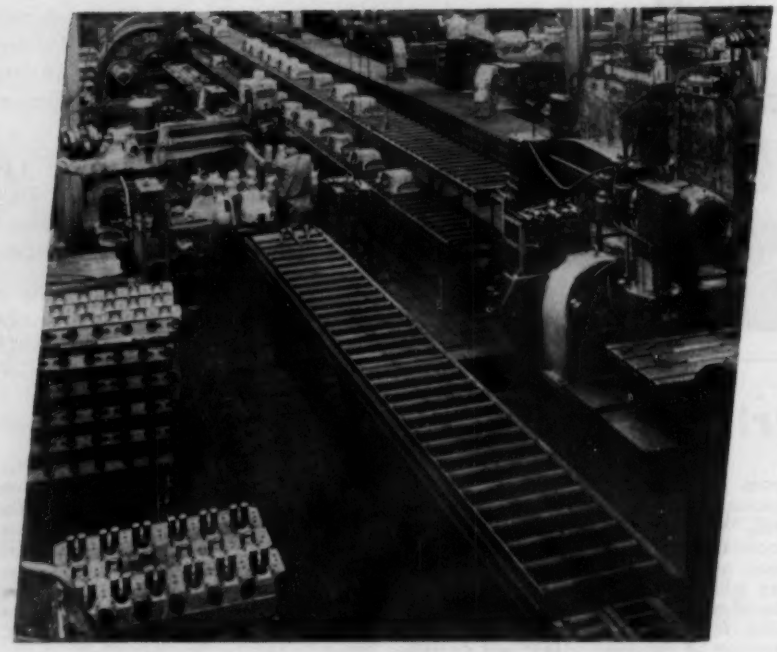
DYNAMATIC®

DIVISION • EATON MANUFACTURING COMPANY

3300 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

MATHEWS

Engineers and Builders of Conveyers and Conveyer Systems for American and Canadian Industry for 50 YEARS . . .



● It was just 50 years ago, in 1905, that the first Mathews Conveyers were designed and built—and applied in a Minnesota warehouse. From that early equipment has evolved some very spectacular continuous-flow conveying systems—indeed, some of the real "show jobs" of the conveying industry.

In these 50 years, Mathews engineers have developed the most complete line of gravity and power conveyers and special conveying machinery to be found anywhere—to serve nearly every class of industry in the United States and Canada.

Whatever is required—standardized conveyer units or a complete system —you'll find that Mathews is your best bet. Three modern plants. Engineering sales offices and standardized conveyer distributors located in most principal cities.

50th Anniversary
MATHEWS CONVEYERS
1905-1955

GENERAL OFFICES . . . . ELLWOOD CITY, PENNSYLVANIA
PACIFIC COAST DIV. MATHEWS CONVEYER COMPANY WEST COAST
SAN CARLOS, CALIFORNIA
CANADIAN DIVISION . . MATHEWS CONVEYER COMPANY, LTD.
PORT HOPE, ONTARIO

Engineering Offices or Sales Agencies in Principal American and Canadian Cities
Export Representative—Foreign Trade Division of New York Hanseatic Corporation

to be held International Amphitheatre, Chicago. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—

Production Engineering Show. Automation exposition to be held Navy Pier, Chicago. Designed to run concurrently with the Machine Tool Show for complete coverage of mechanisms, instruments and equipment which contribute to automation in production and processing. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 12-16—

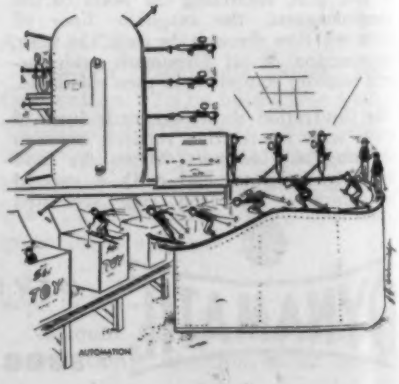
Instrument Society of America. Instrument-automation conference and exhibit to be held Shrine Exposition Hall, Los Angeles. Additional information may be obtained from Fred J. Tabery, 3443 S. Hill St., Los Angeles 7, Calif.

Sept. 14-16—

Association For Computing Machinery. National meeting to be held University of Pennsylvania, Philadelphia. Additional information may be obtained from association headquarters, 2 E. 63rd St., New York 23, N. Y.

Sept. 20-22—

Society of Industrial Packaging and Materials Handling Engineers. Tenth anniversary meeting and exposition to be held Kingsbridge Armory, New York. Additional information may be obtained from society headquarters, 111 West Jackson Blvd., Chicago 4, Ill,



What's New in Mnemonics?

It's the new Univac II—the finest business computing system ever developed. The famous Univac of Remington Rand is still the *only* completely self-checking system . . . the only one which can read, write, and compute simultaneously. And now Univac adds to these superior features the speed of a magnetic-core memory.

Remington Rand has pioneered in this important new development, installing, over a year ago, the first commercially available electronic computer to use magnetic-core storage successfully.

Mnemonics, says Webster, is "the art of improving the efficiency of the memory." And, in electronic computing, the new Univac II carries this art to a point far beyond its contemporaries.

With this new magnetic-core storage, the internal memory of the Univac has doubled, giving instantaneous access to 24,000 alphabetic or numeric characters. If needed, the capacity of Univac II can be further increased to 120,000 characters.

Univac's external memory—magnetic tape—now has greater capacity too, increasing input and output to 20,000 characters per second . . . the equivalent of reading or writing every character on this page more than 1,000 times a minute.

These new Remington Rand developments can be incorporated into any existing Univac installation to double its speed of operation and increase its economy still further. For additional details, write to . . .

Remington Rand

ELECTRONIC COMPUTER DEPARTMENT, ROOM 1742, 315 FOURTH AVENUE, NEW YORK 10, NEW YORK

DETROIT DATELINE

By FLOYD G. LAWRENCE Detroit Editor

PROGRESS WITH IDEAS

PLASTIC ENGINES are being used by Plymouth in readying its V8 engine plant in Detroit.

Heretofore tryout models had been specially cast and hammer-formed jobs which were not only expensive, but also slow in coming. With an August production target date, Plymouth had to have something fast and that's where plastic came into the picture.

Plymouth has used plastic replicas of sheet metal parts for some time to try out handling devices in the assembly and stamping plants. On the same thinking, plastic seemed like a reasonable solution to the cost and time problem for engines, though to the engineers' knowledge such a system had not been used previously in machine tool tryout.

Wooden models of the major engine parts with correct exterior dimensions were made and cast in plaster from which the plastic parts could be made. Eight engines were made in about a week. These were torn down and respective parts shipped to the tool manufacturers producing the various machine tools involved.

Because of the speed with which the models were produced, the toolmakers were able to find out early where possible areas of interference might lie in the machine handling systems which could not be pinpointed by the two-dimensional drawings. Head and block broaches, intake milling machines, etc., all could be checked with this replica of the actual part while the machines were actually abuilding since it was possible to make the models shortly after the design was finalized.

For inexpensive 3-D, it looks like plastic is going to set the pace.

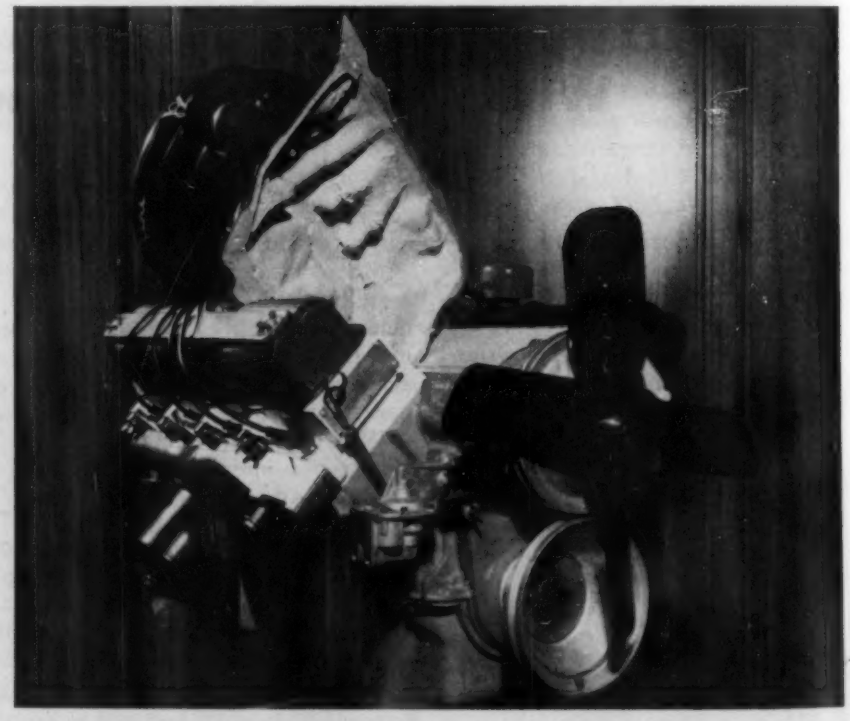
Predicting Design Changes

Engineers in Detroit are growing more concerned about the need for predicting future design changes. This trend is partially attributed to automation.

The basic problem, of course, is the fact that automated equipment is fundamentally special-purpose equipment and as such can be obsoleted quickly by a major change in the design of the part being produced. Production engineers unaware of possible areas of future design change fail to allow sufficient latitude in the equipment to handle changes when they arise.

For that reason, design men are being put on the spot to anticipate where their developments are going to lead with the idea of extending the useful life of the equipment even at some additional initial cost.

The answer of the product design engineers has been in part a



Plastic engines aid tryout of new machine tools for automated line

retort that they have always designed parts for maximum modification without basic change, in part an attempt to accede to the production engineers' wishes and in part a feeling that production engineers should design equipment with the understanding that maximum flexility will extend amortization.

Chevrolet's "segmented automation" is being cited by some as the most illuminated approach to the problem thus far.

Automatic Assembly

Engineers in the Motor City figure the next major area of improvement in automatic processing will be in assembly operations. The increasing cost of labor to be given a sharp hike by recent Reuther assistance as well as the considerable damage to parts through worker carelessness in handling point up the need for the move.

Heavy-Duty Part Balancer

A new connecting rod precision balancing machine that handles a variety of heavy-duty and diesel engine connecting rods from 7⅜ inches to 12½ inches center distance is announced by Snyder Tool and Engineering Co.

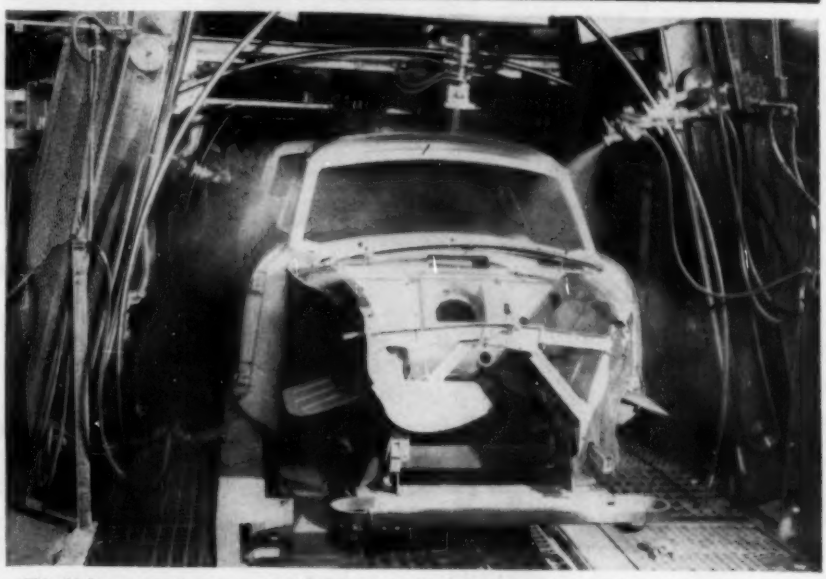
Composed of a milling machine with two opposed double-spindle heads, a console containing all operating controls and a precision weighing unit, the rod is weighed and then milled for removal of the correct amount of balancing stock from lugs provided on the piston and crankshaft ends of the forging.

Only a fixture and clamp detail need be changed to mount different rods in the milling fixture.

Interesting Idea

Changing times have raised the idea around Detroit that perhaps the emphasis in industry of the future will be on how to get the most out of machines rather than how to get the most out of people. Personnel men of the future, they say, may be automation experts.

WHAT'S NEW in automatic systems



This Binks automatic spray painting system tirelessly applies a beautiful finish to the exterior of Nash and Hudson Rambler bodies. Special adaptations permit rapid color changes.

Automatically...Rambler bodies get a perfect finish...every time

Automatic spray painting systems are the surest guarantee of consistent high quality and uniformity of product finishes... and they do the work faster... and more economically.

An excellent example is the automatic finishing system in operation at the Kenosha Assembly Plant of American Motors Corp. This system automatically applies a uniform finish to the exterior surface of Rambler bodies.

A coating of primer and either one or two color-tones are applied to each body as it passes through the Binks down-draft water wash spray booths. Tripping levers automatically activate the spray guns, as they oscillate back and forth over the body. The spray guns mounted at the top of the booth first paint the trunk deck, then as the body moves forward, rise automatically to finish the roof. The guns again lower to coat the cowl. The system automatically compensates for variations in body styles. A similar system is also in operation in the American Motors Milwaukee plant.

Free engineering help.

Automatic equipment of this kind is indicative of what can be accomplished when plant operating engineers work closely with Binks engineers on a specific problem. Binks' broad experience in this field is available to you without obligation. Just contact your nearest Binks Branch Office or write direct to the address below.

2245-55

Binks

EVERYTHING FOR SPRAY PAINTING

GUNS

SPRAY BOOTHS

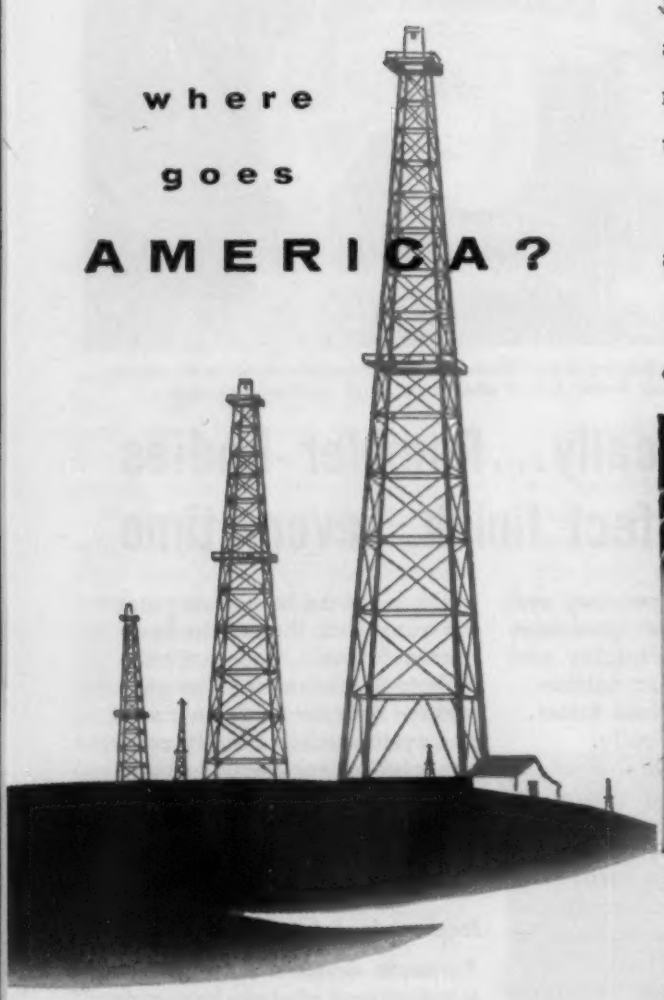
FREE INSTRUCTION

BINKS MANUFACTURING COMPANY

3132-40 Carroll Ave., Chicago, Illinois

REPRESENTATIVES IN PRINCIPAL U. S. & CANADIAN CITIES · SEE YOUR CLASSIFIED DIRECTORY

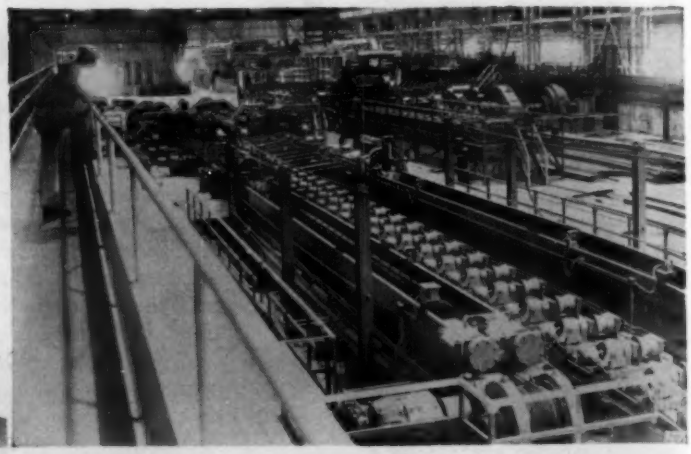
where goes AMERICA?



★ America goes after more and more oil and gas as demands increase . . . up about 5% in 1955. More wells will be drilled, an estimated 54,500. The average depth goes deeper, now down better than 4,000 feet. More and more pipe lines must be built . . . some 14,704 miles planned, approved or authorized. Every year more and more steel is required for production, processing and pipeline transportation per barrel of cubic foot of oil and gas.

All of this activity means more and more oil country goods and much of it will be seamless pipe and tubing.

Are your pipe and tube mills modernized or are you losing out competitively on quality or production?



Most of the ideas about making seamless tubing have been worked out between the steel industry and Aetna-Standard in 54 years association. Many new ideas are available from Aetna-Standard to make your pipe mills more productive. Or, if you are considering new facilities, Aetna has the facts on which to base an intelligent decision.

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

Stabilizing Factor

Have you ever considered the fundamental long-range business aspect of the trend toward more automation? In the rather close-range detailed phases of automation generally discussed today it is likely that the most important long-range factor will be overlooked. It is this long-range aspect that makes automation dynamic and points the way to a new day in everyday economics and living standards.

In evaluating automation applications for all varieties of enterprise, one important statement has been mentioned occasionally by experienced automation specialists — "you can't 'lay off' an automatic line when business is slack". Once the decision has been made and the line installed, business management faces the relentless demand of economics to keep the line in operation. The alternative may be unpleasant—there are no easy "outs".

Automation creates the necessity for producing at a relatively continuous pace without big ups and downs. It demands improved knowledge of market and distribution methods; better product design; increased long-range planning; full co-ordination of production, engineering and sales activities; and provides the strongest of incentives to make profitable output a reality.

The net result of increasing automation thus leads in the direction of leveling out the production and economic cycles. Needs and desires of a growing population never decrease—they will always be present in upward trend. Automation offers the best practical opportunity to fulfill these requirements but at the same time it can contribute mightily toward increased stabilization of business economics.

With full co-operation of management and engineering, with enterprise and imagination, and with a keen awareness that the final justification of industry is in devotion to service and improved living standards, we can look forward to the dawn of a new day in economic history.

EDITOR

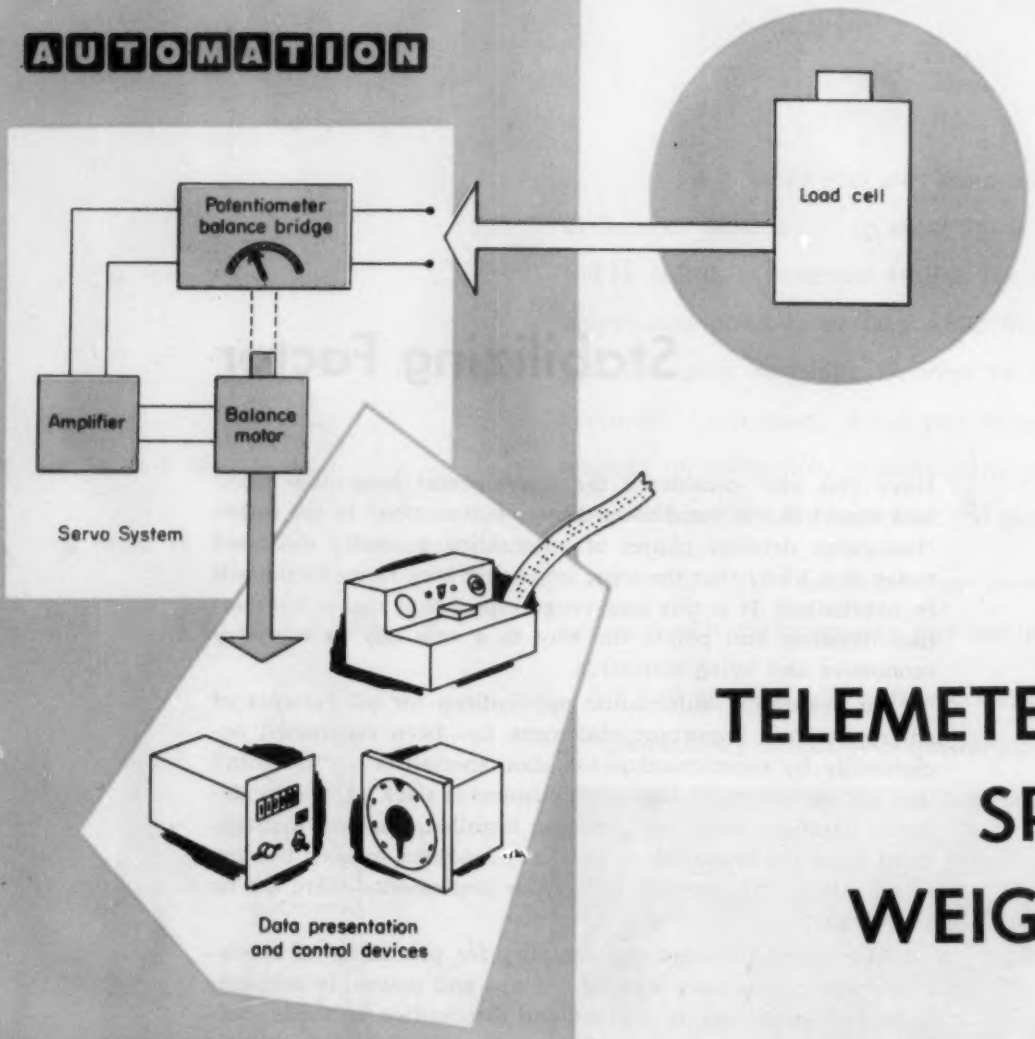


Fig. 1—Basic elements of an electronic weighing system are the load cell, the servo system, and devices for data-presentation or control

TELEMETERING SPEEDS WEIGHING

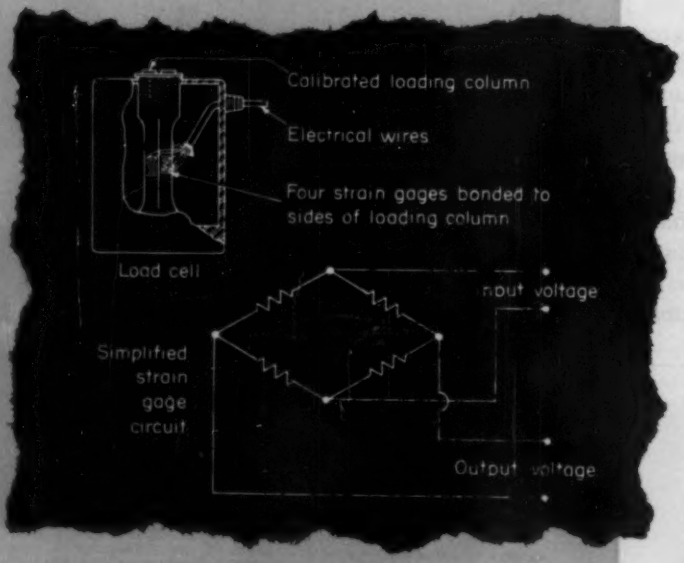


Fig. 2—Force applied to a calibrated loading column causes deformation of strain gages and varies a constant input voltage in proportion to the magnitude of the force

INDUSTRY NEEDS more speed and efficiency in weighing operations used in conjunction with improved methods and machines in the growing trend to automation. Material handling has long been hindered by weighing operations which interrupt the smooth flow of materials, involve multiple chances for human errors, and include costly delays in reporting weights to control points, billing offices, etc. Improved speed, accuracy and data transmission in weighing operations are being obtained by many industries through combinations of electronic weighing and telemetering means.

Electronic weighing systems, *Fig.* 1, consist essentially of three components: a load cell, a servo system, and a data-presentation or control device. Load cells, *Figs.* 2 and 3, are electromechanical units which vary a constant input voltage in immediate response to an applied force and produce an output voltage proportional to the magnitude of that force. The servosystem translates the output voltage of the load cell into a mechanical displacement. Data-presentation devices such as recorders, *Fig.* 4, indicators, or control devices are positioned or actuated by the mechanical displacement from the servosystem.

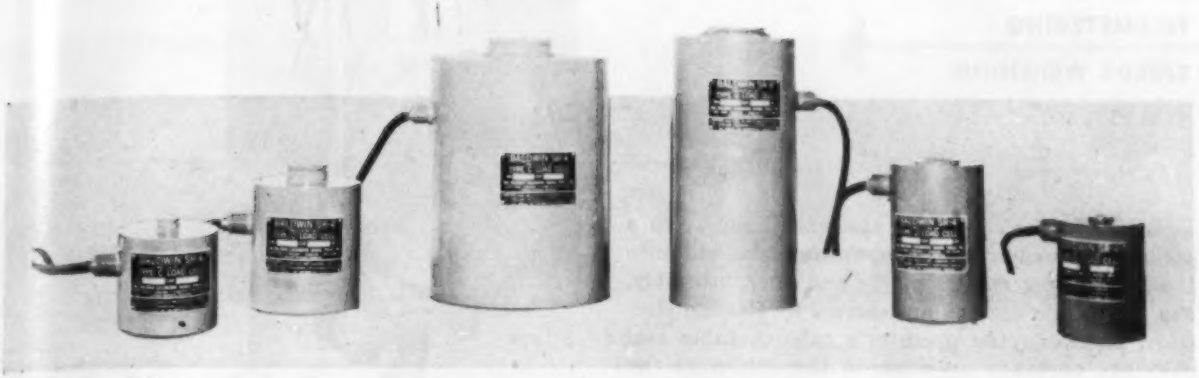


Fig. 3—Compact load cells are available for various capacities and uses. Cells with capacity ratings of 200,000 lb are about 10 inches in height and have an OD of about 7 inches

By ROBERT B. ZILIUS
Streeter-Amet Co.
Chicago, Ill.

Automation of production operations and material movements requires improved methods of weight measurement and transmission of weight data. Heavy items or loads can be efficiently weighed by application of electronic weighing and telemetering techniques

Under normal industrial conditions the accuracy of such weighing systems is comparable with the best mechanical systems. Outstanding advantages of electronic weighing are: (1) The relatively small size of the load cells, (2) the adaptability of load cells for tension or compression applications, (3) that any number of load cells can be used in a single piece of equipment, and (4) that weight information from the sensing units is in the form of electrical signals which can be easily carried to remote locations. These factors give electronic weighing a wide flexibility for variations to suit specific applications. Such systems are also readily adaptable for reporting weight data by use of telemetering techniques to remote central points or multiple points for supervisory, billing, process control and other functions.

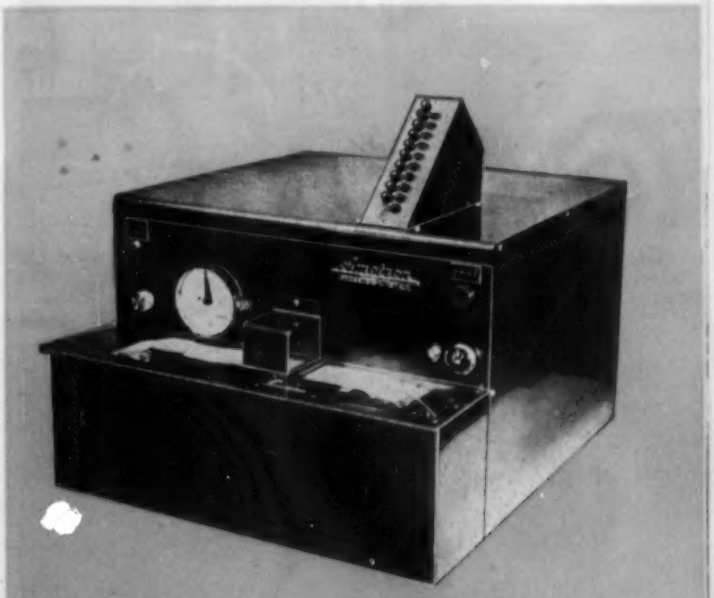


Fig. 4—Data presentation devices are available such as this tape printer which incorporates a weight identification means

▸ Electronic Weighing Applications

An important contribution to industrial weighing is the electronic crane scale, *Fig.* 5. This system combines transportation and weighing of materials into one operation. The crane scale utilizes a load cell sensing unit in the load carrying linkage, either

as an extra hook and cell assembly hung from a standard hook, or by incorporating the cell into the design of a special pulley and hook assembly, *Fig.* 6. Weight signals are carried by flexible electrical cables to the operator's cab. A cable reel pays out or takes up slack in the cables as the hook is moved. The weight of each load supported may then be recorded or indicated in the operator's cab. Almost any crane installation can be readily converted into an electronic weighing unit by simply placing a load cell and hook assembly on the existing crane hook and mounting the cable reel and data-presentation device on the operator's cab.

Truck scales, *Fig.* 7, and track scales are constructed by mounting load cells in a scale pit and placing a conventional type of weighbridge on top of the cells. Pits used for electronic scales are somewhat smaller than those required for conventional beam scales of equal capacity. This results because of the small physical size of the load cells

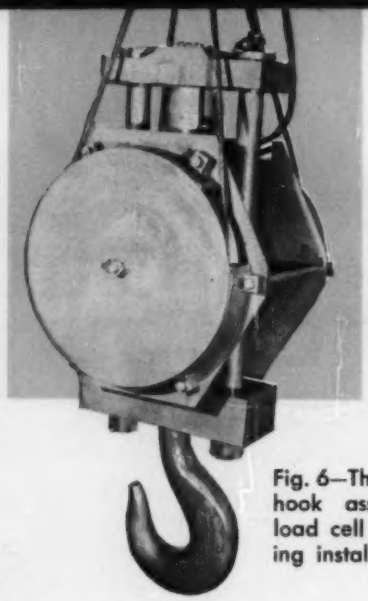


Fig. 6—This special pulley and hook assembly includes a load cell for a crane weighing installation

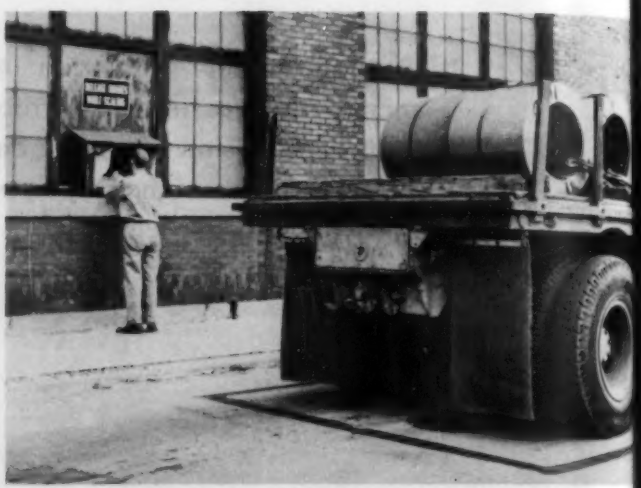


Fig. 7—Electronic weighing installations such as this truck scale can produce a printed weight record for the driver and simultaneously record the weight in shipping and billing offices

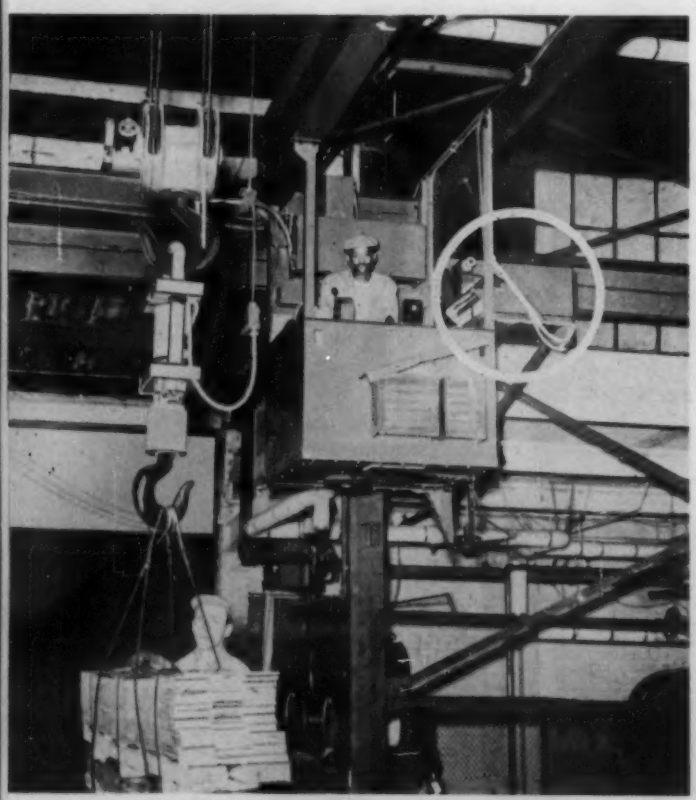


Fig. 5—An existing crane may be converted to an electronic weighing unit by hanging a load cell and hook assembly from the original hook and mounting a data-presentation unit on the operator's cab

plus the fact that there is no need to provide space for a transverse lever. Also, in some cases, the size of the weighbridge can be reduced materially by installing several load cells to support it at many points.

How load cells may be incorporated into the support structure of a hopper is illustrated in *Fig.* 8. If corrosive fumes are present, the fact that the load cells are hermetically sealed units is of particular importance. Various batching sequences may be controlled closely by instruments located at nearby or remote points.

The small size of load cells and inherent advantages of remote weighing indicate worthwhile applications of electronic weighing in various overhead-rail lines. For example, an existing mono-

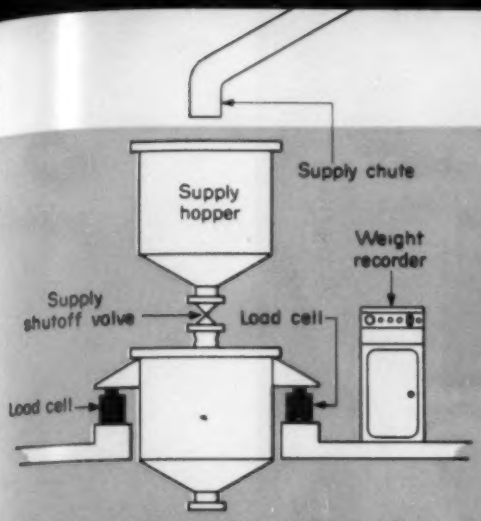


Fig. 8—Hopper weighing setups can be more compact and weight determination expedited by use of electronic weighing

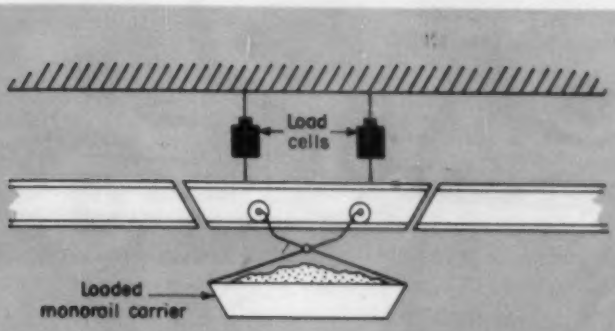


Fig. 9—By supporting a section of the rail with load cells, a monorail conveyor can be easily provided with a built-in weighing station

rail system may be provided with a weighing point by supporting a section of the rail with load cells, *Fig.* 9. The application of such a system to an automatic routing system is sketched in *Fig.* 10. Here the individual loads are weighed on an electronic monorail scale and a drive mechanism is actuated which swings the hinged rail to the rail route corresponding to the weight detected.

One possibility for use of electronic weighing in control of rate of flow is illustrated in *Fig.* 11. Load cells are used to support a tank from which a fluid material is to flow at a desired rate. As the fluid flows out, the change in weight of the tank causes proportional change in the output voltage of the load cells and results in rotation of the output shaft of a servomotor at a speed proportional to the rate of weight change. A synchronous motor is set to run at a constant speed equal to the speed at which the servomotor will run when the flow is at the desired rate. When the desired rate of flow occurs, the two motors turn their respective sides of a differential gear unit at equal rates and the output shaft of this unit remains motionless. If the servomotor either leads or lags the synchronous motor the output shaft of the differential gear unit turns in the appropriate direction and adjusts a flow control valve. Adjustment of the valve can be through direct linkages or from a remote point through a valve motor and controller as shown in the sketch.

▶ Telemetered Weighing

Telemetering systems transmit information fed into them by sensing devices. Data reported by a telemetering system cannot be more accurate than the original information the system receives. By utilizing additional telemetering methods and equipment, *Fig.* 12, innumerable weighing installa-

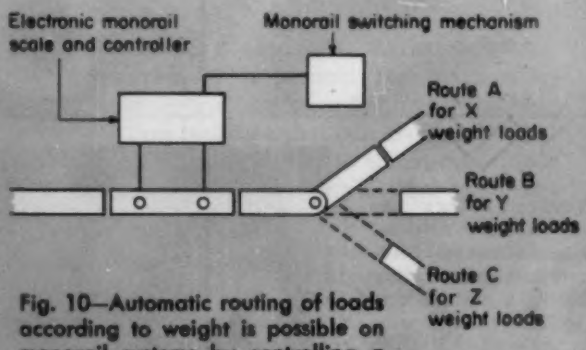

Electronic monorail scale and controller
Monorail switching mechanism
Route A for X weight loads
Route B for Y weight loads
Route C for Z weight loads

Fig. 10—Automatic routing of loads according to weight is possible on monorail systems by controlling a route selection means with data from a weighing station like that in *Fig.* 9

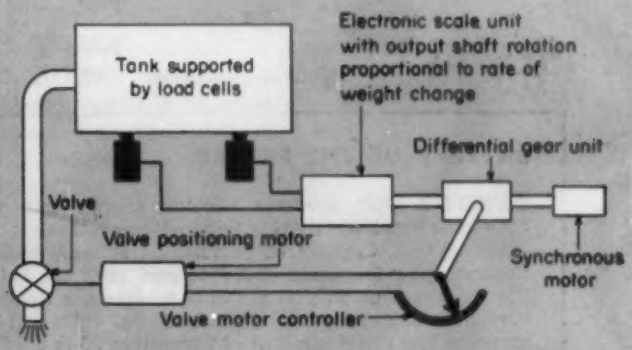

Tank supported by load cells
Electronic scale unit with output shaft rotation proportional to rate of weight change
Differential gear unit
Valve
Valve positioning motor
Synchronous motor
Valve motor controller

Fig. 11—Automatic control of flow from a tank can be based on readings from load cells supporting the tank

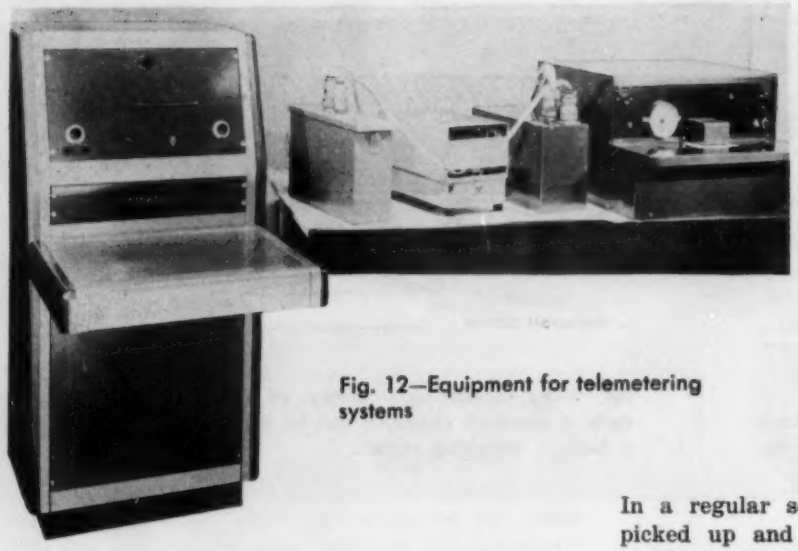


Fig. 12—Equipment for telemetering systems

tions can be adapted for remote reporting, recording, alarm or control. Such systems can be completely automatic or only partially automatic. In recording and reporting with such systems, speed and accuracy are greatly improved. Misreading of figures on indicators, transposing of numbers, loss of readings, and delays of oral or written communications are eliminated or reduced in telemetering installations. Weights can be automatically reported to single or multiple remote control points or data processing centers instantaneously.

Telemetering installations may report readings with systems such as those counting information pulses spaced by marking pulses, systems using long and short pulse codes, or any of a great variety of other means. A choice of transmission methods is also possible. Pulse codes for instance may be transmitted over small gage wires, either privately owned or leased from telephone companies; power lines; or microwave transmission.

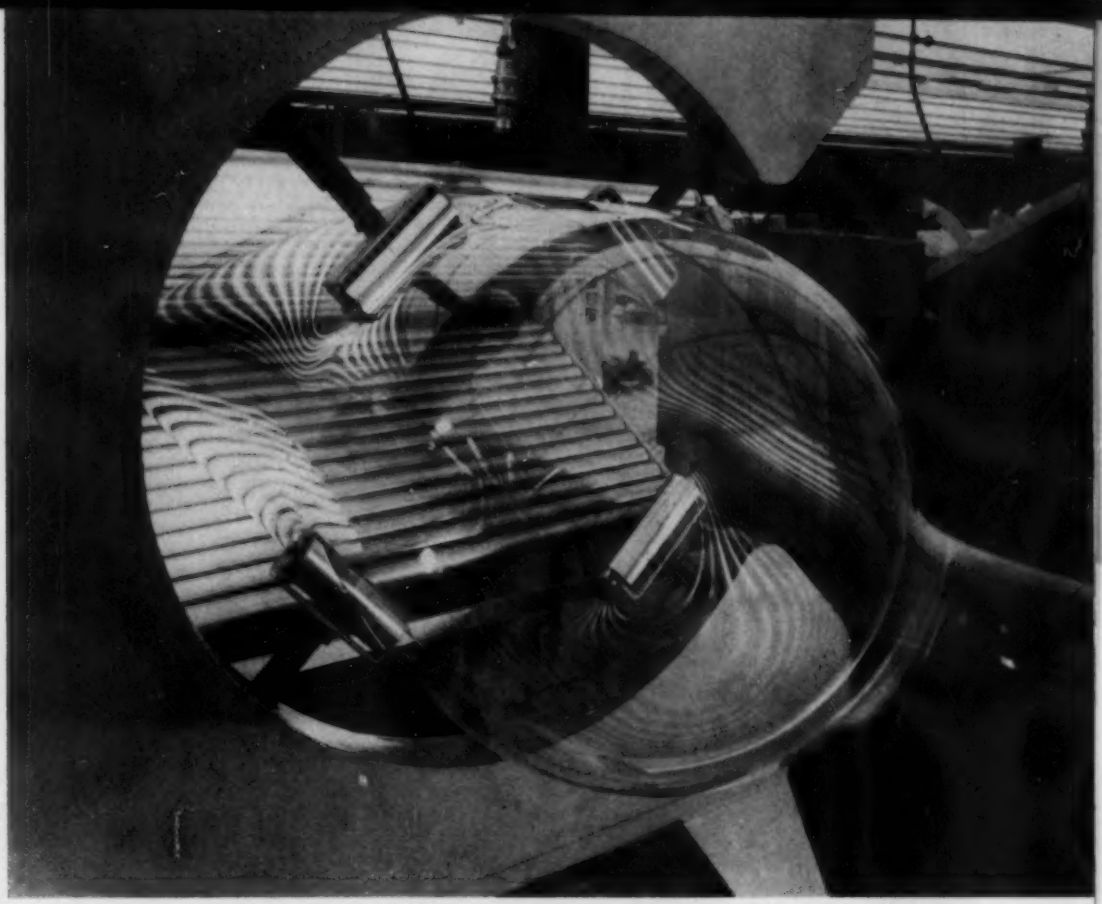
A comparison of typical crane weighing operations with and without electronic weighing and telemetering indicates some of the advantages possible with telemetered weighing. Consider a crane operation weighing steel and loading it on a truck. In a regular scale operation, the steel must be picked up and transported to a scale, lowered, weighed, picked up again, then transported to the truck and loaded. Extra help may be required at the scale to position the load for weighing or men may have to walk back and forth from the pick-up area to the scale. Since the scale location is fixed, extra crane travel is often necessary to take the load to the scale and then perhaps back past the pick-up area to the loading area. A man has to balance the scale, record the weight, and telephone or take the information to shipping, billing, and other departments. Workers in the other departments often must then call or send word back to verify the figures received, time of weighing, whether actual or estimated weights, etc. Multiple chances for delay and error are inherent in this routine.

With an electronic weighing and telemetering system the crane operator picks up the load and goes directly to the truck, stops momentarily, pushes a button, and the weighing and distribution of information is completed automatically. The crane operator puts his load on the truck and returns for another load.

Improvements in techniques and equipment will undoubtedly be made at an accelerated pace, and applications of electronic weighing and telemetering will play important roles in efficiently increasing speed and accuracy of many processes.

BATTERY OF THE FUTURE

BATTERY that converts nuclear energy into electrical energy has been developed by the Patterson-Moos Research Div. of the Universal Winding Co. Capable of performing reliably under temperature conditions ranging from minus 60F to plus 160F the battery has an operating life in excess of 25 years. Three models are available with voltage and current ratings ranging from 1 to 10,000 volts and 5 to 2,000 micromicroamperes.The disintegration of Strontium 90 is used as the energy source; and the company states that the external radiation of the battery is within the Atomic Energy Commission tolerance limits. High voltage battery supplying 10,000 volts at a current rating of 500 micromicroamperes is less than 5 cubic inches in size.



1 In the manufacture of Saran Wrap frictional and applied heat convert the polymer into a molten condition which is die formed into a tube as it leaves the mouth of the extruder. The film is oriented, or stretched, by injecting compressed air into the tube and forming a "bubble" averaging about 80 inches in circumference and 0.0005-inch thick. Rollers guide the film into position for deflation.

AUTOMATION TODAY

PRODUCING PLASTIC PROTECTION

TO PARALLEL a successful market development program of a product for nationwide household consumption the manufacturer must establish production facilities that can keep pace with demand. Having sold saran film to commercial food packagers since 1948, it was natural that the Dow Chemical Co. consider making the same product available as an all-purpose household protective wrap for refrigerator and general storage purposes. After a test-market program in four Ohio cities in 1952 the film was introduced nationally in October 1953. At that time sales totaled 130,000 rolls per month—within ten months this rate had increased to over 3 million per month.

To keep pace with demand Dow's engineers devised a new plant production facility. The Austin Co. handled construction work utilizing the shell of an existing building and the resulting 100,000 square feet of floor space accommodates production capacity for over 5 million rolls per month.

In addition to modern production equipment this plant applies the techniques of automation to the entire operations as evidenced by: (1) A teletype system which assures shipment of orders on the date of receipt by producing necessary paperwork in a single operation—this includes cutting a stencil which is used in an automatic applicator in such fashion that each case is imprinted with name and address of the consignee; (2) a receiving system which can move raw material directly from the truck, up through the storage area and into the production line without intermediate han-

2 Tube stock is compressed and wound into a mill type roll. This view of the film extrusion room shows the series of winding machines. Quality of product is maintained by skilled operators and inspectors charged with the responsibility of removing any inferior film which would be unacceptable for the end use of food wrapping.

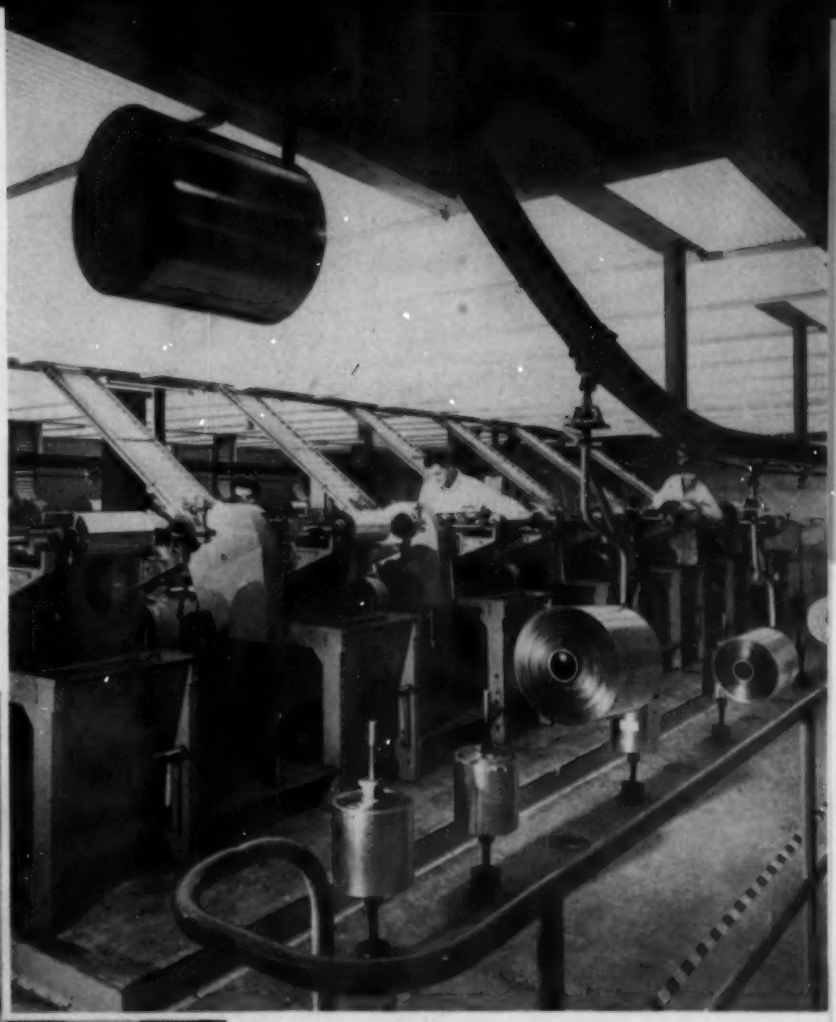
dling; (3) materials handling systems consisting of power belt, gravity roller, gravity skate wheel, power roller, overhead cable, and telescopic boom types of conveyors permitting material to be handled with a minimum of physical effort.

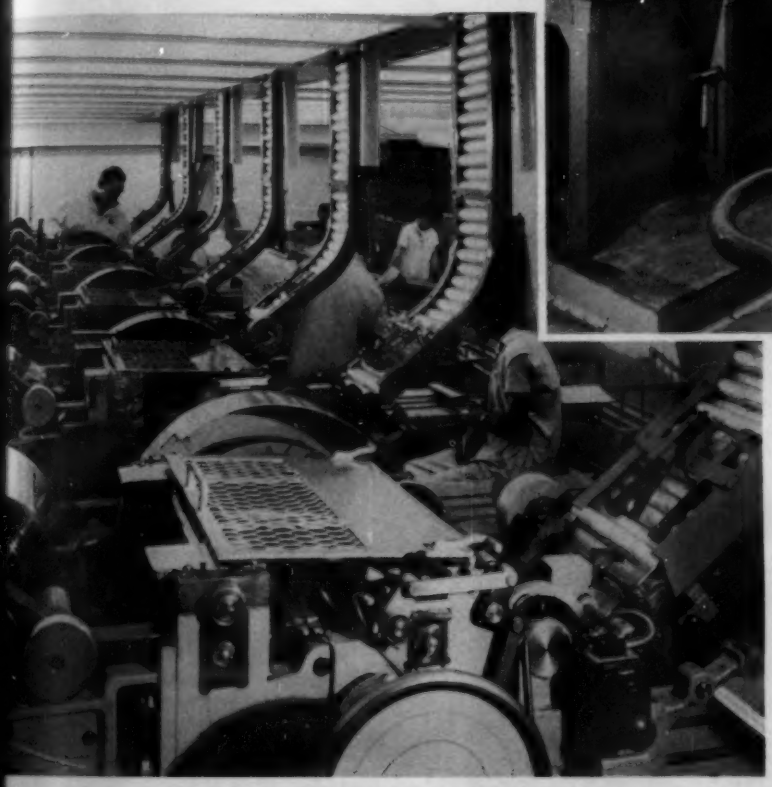
Dry granulated polymer is received in 250 pound fiber packs and is fed into extruders to start the production process which is shown in the accompanying picture story.

3 These machines, originally standard equipment in the paper and tape industries, have been redesigned and modified to slit saran film to desired widths. The long rolls shown in the foreground are to be slit and rewound at 1000 feet per minute into 10,000 to 30,000 lineal foot mill rolls.

4

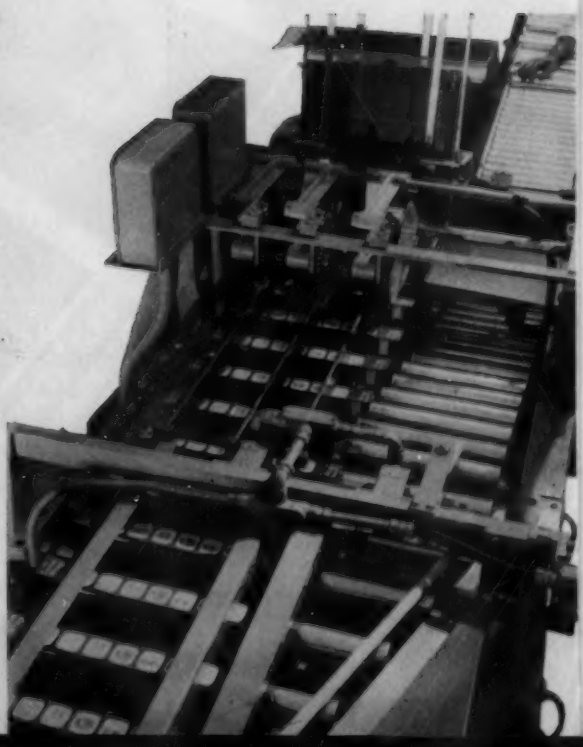
All first and second floor operations are connected by an overhead cable type conveyor which moves the intermediate jumbo roll of film from the slitting room area on the ground floor into both storage and automatic winding areas. The speed of this conveyor is such that operators at any point in the manufacturing plant may place rolls on the conveyor or remove rolls while the conveyor is in motion.





5

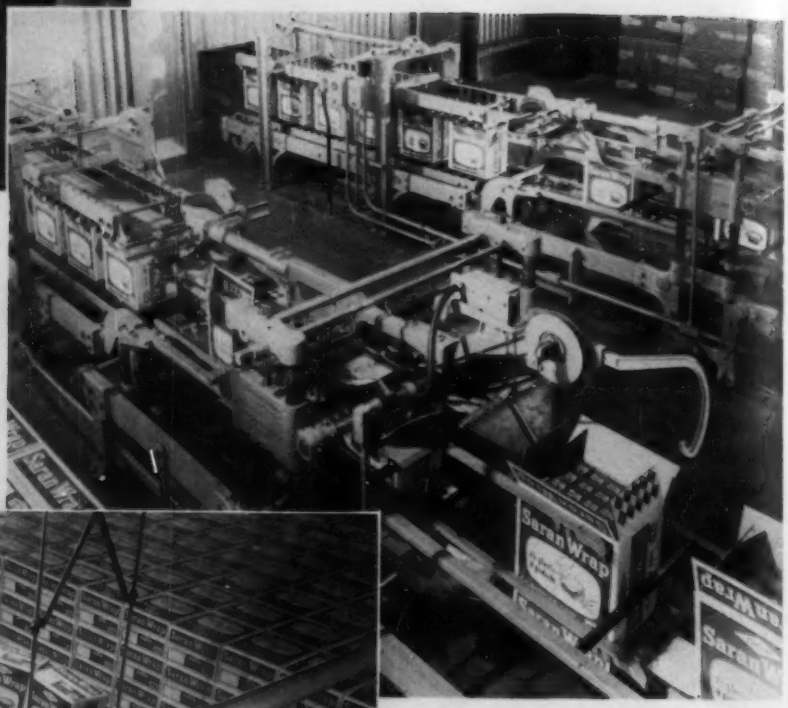
Paper cores are hopper fed from the floor above to winding machines that place the desired length of film on each core at the rate of approximately 20 rolls per minute. Film is automatically cut to length and embossed on the leading edge for easy use. These rolls are discharged onto a conveyor which retains identification of individual machine product and transports it to a gathering station.



6

Rolls are released from the collecting station with leading edge always following a predetermined position in the dispenser box. This automatic packaging machine opens the presealed dispenser box, inserts the roll, positions the roll in the box and glues the ends.

7 As the boxes are conveyed to the case stuffer, belts hold the freshly glued ends until set. When these boxes arrive at an automatic feed station, six successive moves will package 24 rolls in each shipping container.



8 Filled cases move into the case sealers where flaps are folded, glue is applied and the top and bottom sealed simultaneously. Finished cases move out of this area on powered belt conveyors.

9 Complex system of belt and skate wheel type conveyors moves the cases into a shipping-storing area on the mezzanine floor; or diverts cases to any one of four loading doors or four loading bays on the ground floor; or switches them to a 600-ft long powered belt conveyor carrying the product to a rail siding.

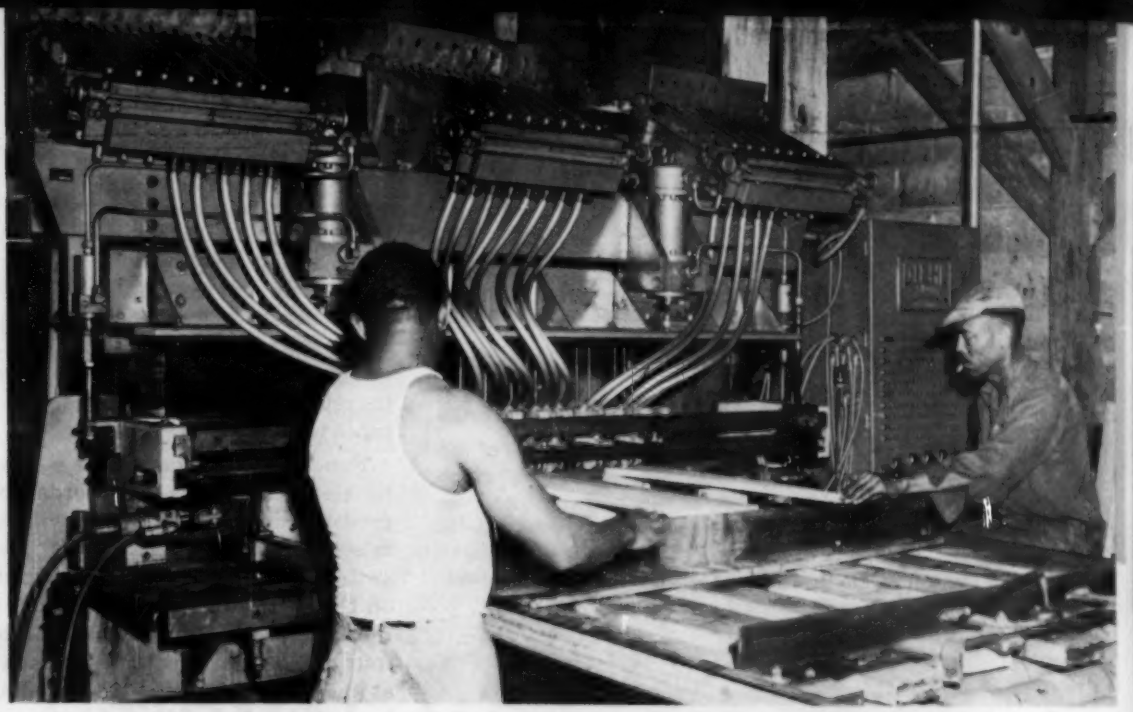


Fig. 1—This nailer operating in a pallet making plant illustrates the design of flexibility into automatic nail feeding equipment

VERSATILE AUTOMATIC NAIL FEEDING

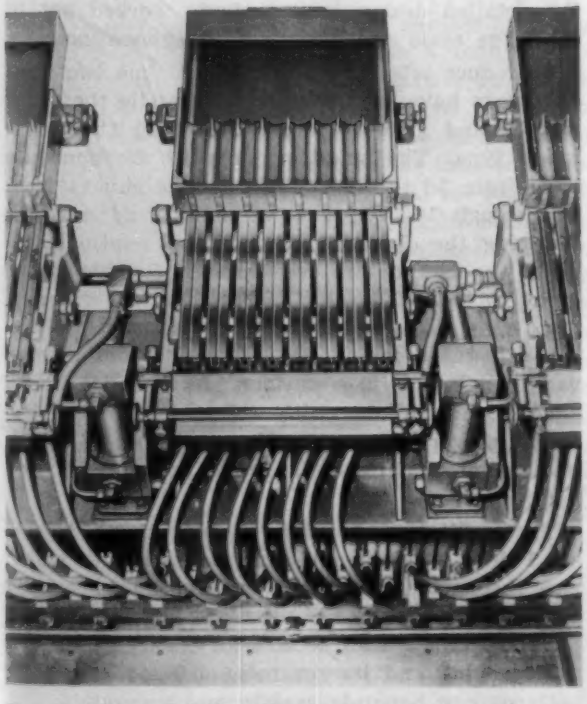


Fig. 2—Rise and fall of the hopper pan in each feeder feeds nails to eight gravity slides. Spring clips can block off any slides not being used. Selectively actuated solenoids allow nails to fall as desired

FLEXIBILITY OF APPLICATION has often been limited in the trend to more automatic machines and equipment. Many highly automatic devices are designed for a specific model of a particular part and can perform only an unalterable sequence of operations; or the changing of complicated linkages or circuits may be so involved that it is impractical to alter the program. Many producers cannot utilize such single-application machines efficiently, and there is a real need for automatic machines designed so that a variety of programs may be readily substituted as required.

With this problem in mind, the G. M. Diehl Machine Works Inc. designs mechanical components for flexibility and installs versatile electric programming and control units designed and manufactured by The North Electric Mfg. Co. Diehl offers high-speed multiple nail driving machines which automatically feed and drive as many as 24 nails simultaneously and cycle through ten successive nailing combinations.

Nailers such as shown in *Fig.* 1 position and selectively feed nails by gravity through plastic tubes to nail chucks. A hydraulically actuated slide then simultaneously drives all the nails held by the chucks. The feeding system is the very heart of this machine and consists of the hoppers which

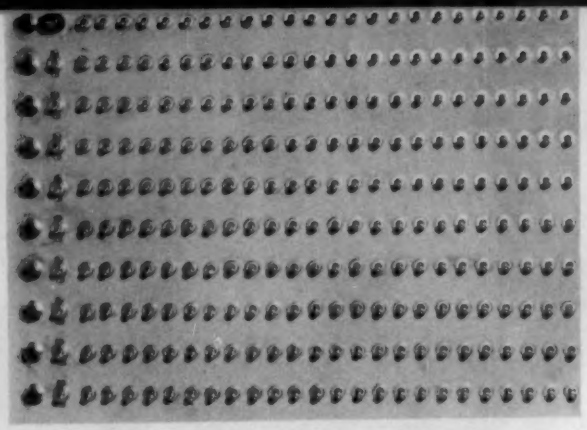


Fig. 3—Switches on this panel permit preselection of the number of successive combinations, up to ten, which will be used; and selection of the particular nail releasing solenoids, up to 24, which will be actuated for various combinations. One of the lamps in the column at the left of the panel lights to indicate to the operator which pattern will be next

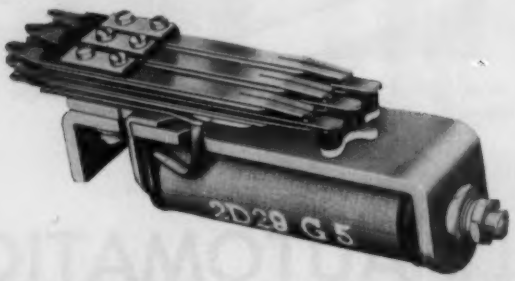


Fig. 4—Compact telephone type relays in a chain are stepped by each operation of the nail driving slide. Each of these counting relays closes the circuit to a solenoid control relay

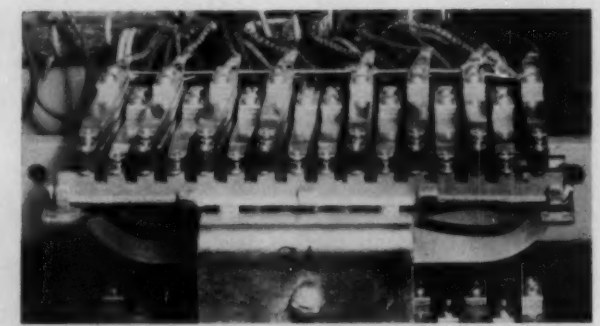


Fig. 5—Multiple contact relays in this machine act as solenoid control relays. To increase life of these contacts a single large contactor makes and breaks the power circuit to the solenoids while these contacts are closed

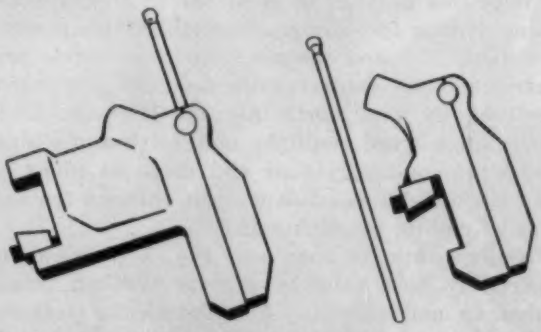


Fig. 6—Nails fall through flexible tubes to the chucks. Various chuck sizes and styles facilitate changes in nailing specifications. The heads of the nail driving punches engage slots in the face of the driving slide and move up and down with it

orient and feed the nails, selective release controls, and the nail chucks with their feeding tubes.

The hoppers are oscillating pan type units which orient nails point down and each feed eight gravity slides, *Fig.* 2. Mechanical design of the feeders is such that they may be readily adjusted to accommodate 2d to 10d nails; and since there are three separate hoppers, three different sizes of nails can be used simultaneously. Solenoids at the bottom of the slides are automatically actuated to release nails which then fall through plastic tubes to the chucks.

Functioning of the release solenoids is controlled by electrical relays in accordance with a pattern predetermined by manual switches. The pattern selection panel is shown in *Fig.* 3. The nine switches in the first column of switches at the left on the panel determine how many nailing combinations, up to the ten possible, will be used. Twenty-four independent switches in each of the ten lines at the right determine which release solenoids will be actuated for each combination used. Additional switches partially shown below the selection panel in *Fig.* 1 allow the operator to regulate stepping from combination to combination manually if desired rather than automatic stepping with each stroke of the nail driving slide.

Stepping to successive combinations and simultaneous actuation of nail release solenoids for each combination is performed by telephone type relays, *Figs.* 4 and 5, which are magnetically operated switches. This type relay may be readily adapted to machine control since that involves only another application of its originally developed function, and can give machine controls the benefit of the detailed design improvements worked out in the large scale applications of telephone usage.

To reduce set-up and adjustment time two sizes of chucks have been designed to handle the usual lengths and gages of nails, including the drive-screw type. The small size chucks accommodate nails from 2d through 5d, large size chucks from 5d through 10d. Spacing of nails is adjusted by clamping the chucks in the desired relationships. Since the chucks are fed through flexible tubes, great variety of spacing is possible, and different size nails from separate hoppers may be fed through tubes which are crossed to intersperse varied nail sizes in a pattern. As seen in *Fig.* 6, chucks are available with different clamping bar to nail driver distances so that nails can be driven in staggered patterns as well as straight line patterns.

The application shown by *Fig.* 1 is in the Arkansas Pallet Co. plant. Stock is placed in jigs which pass through the nailer on a conveyor. On seasoned oak this installation has produced from 500 to 800 pallets per day—and because of the versatility of the machine and its controls, changes in nailing patterns can be made rapidly and accurately.

Technical journals occupy a unique position of being able to render service in the way of crystallizing new thinking in any technology. Occasionally, a new thought is expressed in a suggestive form at first, but if, where and when a need exists, it can be expected to stimulate the interest necessary for complete development. The significance of this article is best expressed in the authors' words —"What we have tried to do is discover the least number of concepts which will enable us to describe the various methods of producing work in a highly technological society. These basic concepts we believe to be two: the parameters of information and energy, together with their various subclasses. Working with these materials we have attempted to prepare a chart of devices that is analogous to the periodic table of the elements put in its modern form by Mendeleev in the middle of the nineteenth century. Although the chemical elements are quite different from machine elements, we believe there remains some ground for considering this analogy useful"

A FUNCTIONAL MORPHOLOGY OF MECHANISMS

By **E. W. LEAVER** and **J. J. BROWN**
President, Electronic Associates Ltd., Toronto, Canada
Staff Member, Aluminum Limited Group Co., Montreal, Canada

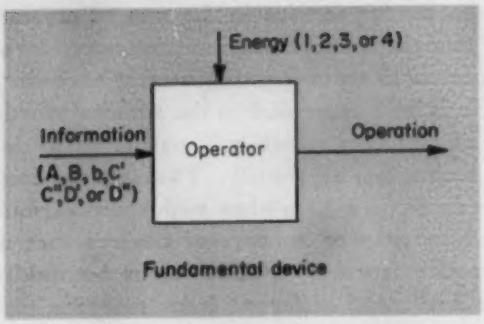
QUANTITY PRODUCTION has involved and probably always will involve a multitude of repetitive operations. The alternative to the use of men in these tedious, routine jobs is to make machines operate themselves. The idea of automatism probably dates back to the time when the first user of a hand tool wished that the tool would go on performing the work, leaving its owner free to go about more entertaining business. The development of automatism has taken place in orderly stages; it began with the primitive situation where man was forced to produce goods with his unaided hand, and it will end, we believe, with the high degree of automatism which we predict for the future, when automatic machines will be widely used to produce and distribute many goods and services.

Machine-Man Complex

Western society, in its material aspects at least, consists of an arrangement of men and machines by which the necessities of life are produced and distributed. This arrangement of men and machines into an organization more or less closely integrated we call the machine-man complex. This complex has existed for ages but the nature and arrangement of its components has varied from time to time. For example, the function of the slave in primitive societies was in many ways similar to that of today's automatic machine.

Over the centuries the trend has been toward less and less work by men and more and more work by machines. If we consider animals of burden to be one type of machine, this tendency can be traced very far back into historical times. Until quite recently, however, the nature of the machine-man complex changed very slowly with time. The Industrial Revolution, beginning in the eighteenth and reaching its full power in the nineteenth century, caused a major change in the machine-man complex. By the use of such concepts as interchangeability, steam power, mass production, and standardization, a firm groundwork was laid for the complex industrial society we know today. However, in spite of our extensive use of tools, machines, and other devices for helping us get our work done, we believe that such devices are still not very well understood. We believe further that whether or not the Western world is ready for it, highly industrialized countries like the United States are going to move relatively rapidly in the direction of greater use of automata, and even towards some fully automatic factories.

This trend toward higher degrees of automatism can go in one of two directions. The first possibility is to make the machines more and more automatic yet not automatic enough to get rid of the



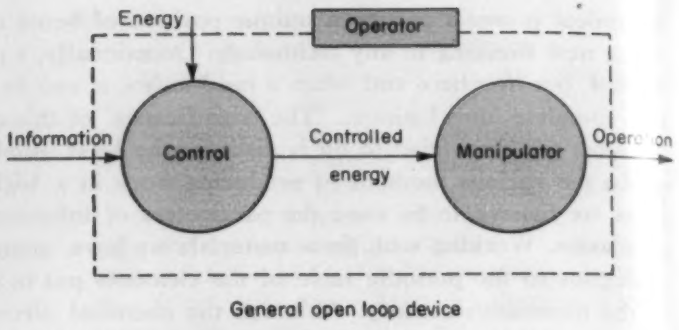
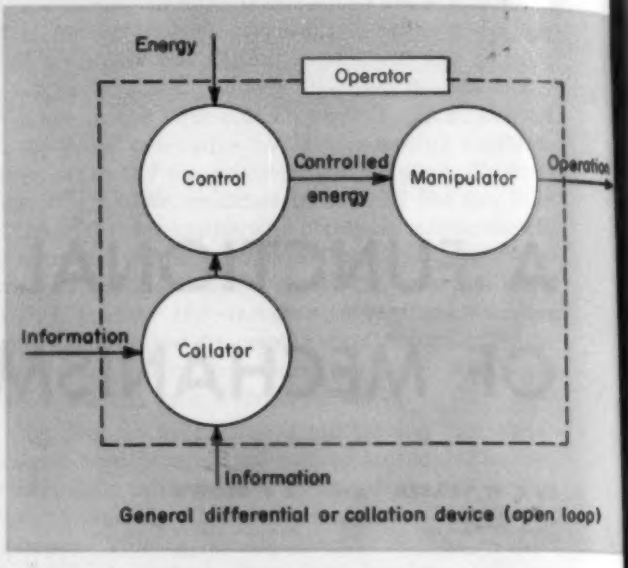


Fig. 1—Fundamental scheme of control systems. In these systems a device is defined as an operator on energy and information which provides a resulting operation. The information, energy and operation may be in any form, such as manual, mechanical, electrical, chemical, etc. Although any device with a human being in the chain may be considered a closed loop, unless the feedback is built into the device itself, it is classified as open loop



worker entirely. In this situation the worker has somehow to be synchronized with the machines. To a considerable extent the machine must dictate his working rate. In a word the machine, not the man, is the master. This has already happened in many plants, and has caused some cries of alarm. Some writers fear this kind of automatism will lead to a new enslavement of the worker, this time to all-powerful machines. Charlie Chaplin's "Modern Times" is a satire on this theme. In a more serious vein, both Lewis Mumford and Stuart Chase have described the difficulties of this kind of machine-man organization. We feel that this situation, which is not uncommon today, is the result of a misapplication or a misunderstanding of automatism.

The second road leading to the development of higher degrees of automatism is efficient division of labor in its highest sense. There are some things that men do uniquely well, and other things that machines do well. This second approach would begin with a study of men and machines with a view to finding out the characteristic excellences and faults of each. Then, when we know the kind of work men do well and the kind they do badly, we can arrange to have machines take over those activities for which men are not well suited. Among the basic principles of automatism we laid down in an article in *Harper's* in 1951 was "routine means machine". We still feel this is a fundamental concept. One of the things that machines do supremely well is routine work. Yet at the same time men do this kind of work badly. Thus any kind of work that is repetitive and boring is a likely candidate for automatization.

The best way to approach this second road to automatism is to develop an understanding of the raw materials we have to work with. In fact, we would go further and claim that if higher degrees of automatism are going to produce more good than harm, we must develop a more adequate understanding of the tools, men, machines and automata comprising the basic raw materials of automatism.

A Classification Scheme for Devices

In an effort to improve our own understanding of these admittedly complex materials we have prepared a morphology or classification of the devices used by men to get work done. A "device", for the purpose of this discussion, is something whose usefulness lies in its movement. An ornament, for example, does not fit into this category, nor does an ash can. But a garbage disposal machine does, and so does a knife.

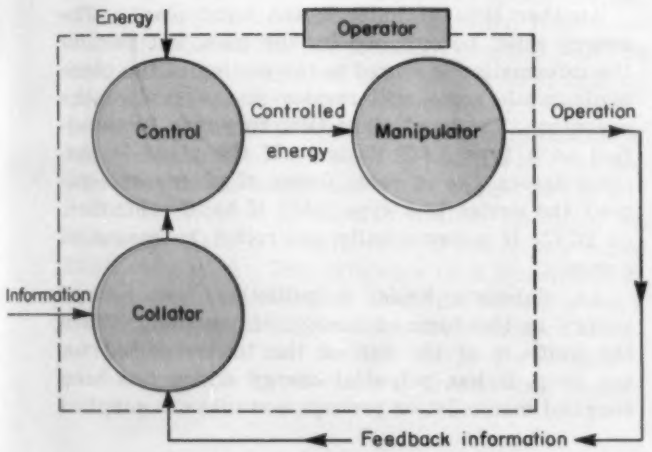
The problem of any classification is to arrive at a suitable number of reasonably useful independent criteria. Inevitably a whole series of judgments is involved in a project of this kind. One almost automatic judgment we all make is to place what we consider the more important properties of an object first. For example, when we talk of an automatic refrigerator it is a moot point whether the automaticity, or the refrigeration, is the most important aspect of the machine. The point is that both aspects are important. The one we consider most important would depend on circumstances at the time. Moreover, classifications by their very nature must always involve twilight

zones where the devices shade off into each other. In these twilight zones there is always room for argument as to whether a given device belongs in class A or B.

In our scheme we consider that the two major parameters are energy and information, i.e., the directive overriding control of the device. Both of these must be present. Either one may be supplied manually or nonmanually, and either may be used immediately or may be stored. The possible combinations of the basic parameters of energy and information are shown in TABLE 1. Since all devices require both information and energy, each one must utilize at least one item from each class, but any one of each set can be combined with any one of the other set.

Collation

Many devices fall into the category in which two sources of information are compared or collated and the result is used for controlling the device itself. Some devices using stored information fall into this category. Feedback devices are a subclass of this group in which a comparison is based in part upon information from the resultant. The fact that collation rather than just association is occurring we indicate by parentheses around the two factors involved. For example, if a fan motor is to be turned *On* should the temperature exceed 20C and a thermostat is used to do this job, the combination of the thermostat and motor would be a device of type 2(*BC'*). This is because it is power-line operated—2, the temperature is immediate nonmanual information—*B*, the turn-on point is manually set, i.e., "stored"—*C'* and comparison is used to determine whether the device is *On* or *Off*—( ).



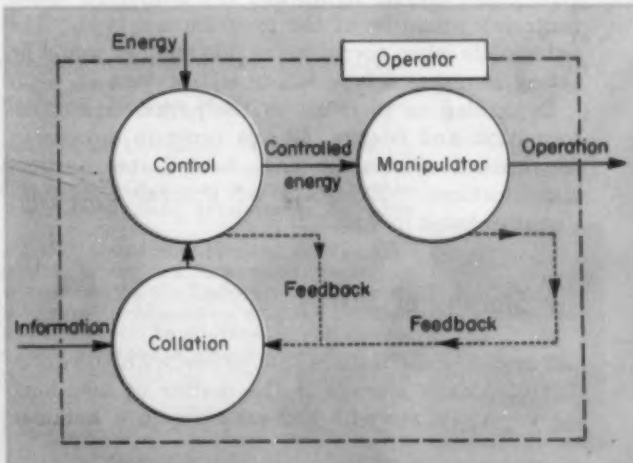
General closed loop device (over-all feedback)

When the collation is between fixed information and some feedback information, the latter is nonmanual—usually immediate or functionally so. Delays to prevent "hunting" or to compensate for "lag" are not considered. Hence, the information is type *B*. But since the feedback information comes as a result of the operation rather than from an independent source, we designate it by the lower case *b*. The negative feedback type of device will therefore be of the (*b*) type, the parentheses indicating the comparison against primary information. For example, a "master-slave" device using controlled electric motors to produce remote movements, and using feedback, would be a type 2(*Ab*) device. With the types of information and energy defined, we are now in a position to set down a fundamental scheme of control systems, as in *Fig.* 1.

Problems of Classifications

In classifying various devices a serious problem appears at once. The question is: wherein lies the greatest functional value of the design? Or, what is the device's main job? To ask this question often resolves the problem. This is the case in classifying the automobile and the hammer. But some cases are more difficult. For example, the hand plane certainly contains some information as to depth of cut, yet it cannot supply its entire information requirements. Skill is still required on the part of the operator. Similar devices are the hand drill, the bicycle, and to a lesser degree the hand date stamp. To an even smaller degree the company seal, or the manually energized punch press require some skill on the part of the operator. We propose to type such mixed devices in terms of their major functions. For example, a hand plane we will classify as type 1*AC'*.

It should be emphasized that this classification is in terms of function as the external environment sees it, and in its most usual or desired application. A device could move from one classification to an-



Alternate forms of short loop (not over-all) feedback

TABLE 1
Basis of Classification

CONDITION	CLASS	
	Energy	Information
Immediate—Manual	1	A
Immediate—Nonmanual ...	2	B*
Stored—Manual	3	C**
Stored—Nonmanual	4	D

*Information affecting device from independent source is designated type *B*; feedback information resulting from an operation is considered a special kind, type *b*.

**Since stored information may be a pattern (all available at one time) or a program (distributed over time), *C* may be divided into *C'* (patterns) and *C''* (programmed); similarly *D* may be divided into *D'* and *D''*.

other if its structure were able to permit its functioning in multiple uses. For the purpose of this article, devices will be considered only as they appear to the external world. We propose to ignore completely the interior nature of the device. For example an automobile has many automatic features, but in order to be used in the normal way, someone must drive it, that is, supply all the information necessary for determining its course. Hence the information is immediate and manual —*A*. The needed energy is supplied from a fuel which is poured into a storage tank as needed. It is therefore nonmanual and stored —4. On these grounds we classify an automobile used in this manner as a type 4*A* device. To be rigorous we must admit that some human work is involved in steering a car and in operating its other controls (i.e.—1). Purists might therefore class an automobile as type 4*A*1. But with the use of power steering and power braking, cars are gradually approaching closer to class 4*A*.

If the automobile of the future were to be driving on a road and a switch thrown which would actuate control mechanisms which would steer, control the speed to the value appropriate to the traffic zone, bring the car smoothly to a stop at adverse traffic lights, and accelerate from the stop to a proper running speed all automatically, then when the car was operating in this way all the information would be stored manual—*C* rather than immediate manual —*A*. Some of the information relating to speed zones and so on would be of the pattern type, some (the timed traffic lights and the automatic speed controls) would be of the programmed type. The automobile when operating in this manner would be acting as either a type 4*C'* or 4*C''* device.

Depending on their use of the parameters of information and energy, all the common devices in use around us can be made to fall into various classifications. Examples of general classifications are listed in TABLE 2.

▶ Storage of Energy

One of the difficulties that arises with the question of energy storage is the matter of how long the energy is stored. For example, in a hammer the energy is stored for the duration of the stroke. In a guillotine the energy is stored until the moment of the drop. In a spring-drive clock the energy may be stored for a day, a week or even a year.

One criterion as to whether in any given case the energy may be considered to be stored or not is whether the storage is externally significant simply as storage. For example, in the punch press, energy is stored in the flywheel of the machine in order to obtain great peak power without excessive drive energy capacity. Energy is, however, still applied externally and continuously, and hence this is a type 2 device as far as energy is concerned. The hammer is a simpler example of the same situation. It is a type 1. The pneumatic hammer considered by itself runs on stored nonmanual energy, contains some stored programmed information, and is manually directed. This latter point we consider to be its most important characteristic, hence we class it as type 4*C'*.

With the development of technology a simple device often passes through a good many of the stages in TABLE 2. For example, the progression of the knife and allied devices through the table might be instructive: A knife possesses sharpness and strength. It must be externally guided and also must be externally supplied with energy. In the case of a knife both of these are usually manually supplied. Hence it may be classified as type 1*A*.

Another type of knife is the hand plane. The energy must be supplied by the man, but part of the information is stored in the setting of the plane blade, while some still resides in the skill of the operator. The hand plane therefore may be classified as a type 1*AC'* device. If the plane is machine-driven (as in some forms of planer or scraper) the device is a type 2*AC'* if hand controlled, or 2*C'C''* if automatically controlled by means of a cam.

An elaborate knife, a guillotine, uses stored energy in the form of energy of position. When the knife is at the top of the tower, poised for the drop, it has potential energy which has been supplied manually, or perhaps nowadays is supplied

TABLE 2
Examples of General Classifications

Tools	1, A
Machines	2, 3, 4, A
Dies and Patterns	C'
Records, Programs	C''
Temporary Automata	3, 4
Triggered Automata	2A, 3A, 4A
Automata	2, B, C', C'', D', D''
Collative Automata	2, (BC'), (BC''), 3, (BD'), (BD'')
Feedback Automata	2, 3, 4, (b)
Sensor Automata	B
Programmed Automata	C'', D''
Pattern Automata	C', D'

by an electric motor. Manual information is also stored in the ways or guides for the knife, and in the knife itself (its pattern). The guillotine, therefore, is a type $3C'$ or $4C'$ device.

It should be noted that in arriving at all of these classifications we utilize only the primary features of a device. Moreover, classifications, it should be remembered, are always arbitrary and always, by necessity, incomplete. Our feeling, however, is that in spite of these limitations, a classificaton system of some kind is badly needed. A limited listing of a few of the more commonly used devices, together with their classification under our scheme are shown in TABLE 3.

In a coin-operated vending machine, the actual dispensing is programmed from stored manual information. Hence it is type C. The energy is usually supplied from the power line so it is type 2. The insertion of the coin involves an insignificant amount of work, but it does supply information as to "when" and "if". Hence we would classify a coin-operated vending machine as type $2C''A$.

How about an automatic lathe? If an operator has to feed the machine more or less continuously he plays an important part in the production process. Hence we would classify this situation as $2C''A$. If on the other hand, the machine is completely self-fed, then functionally, from the point of view of production, it is independent of human attention and would be classified as a $2C''$ device.

A liquid level controller is usually operated from the power lines (class 2), is controlled from non-manual information immediately supplied —B, in conjunction with manual information built into or put into the device —C'. The manual information, however, is obtained from the liquid level which in turn is controlled, so that B is really b and the designation of the device as a whole should be $2(C'b)$.

The analogy of a chart of devices classified by this system and a periodic table of the elements has been suggested. The existence of a classification system for the chemical elements played a very important part in the development of modern chemistry. Holes in the periodic table, for example, made it possible for chemists to predict with reasonable accuracy the existence of elements which have been seen in their physical form only recently. It is our hope that this functional morphology of mechanisms may perform a somewhat analogous function in the world of machine technology.

TABLE 3

Examples of Classification

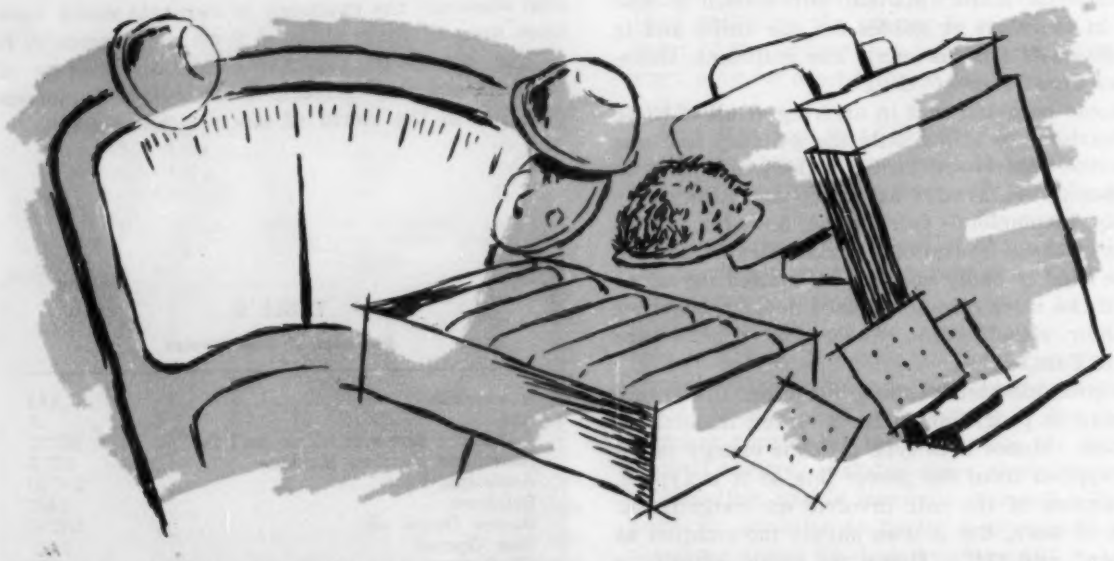
Automobile	4A1
Axe	1A
Automatic Screw Machine (self fed)	2C''C'
Automatic Vending Machine	2C''A
Automatic Pilot	2(C'b)
Bulldozer	2AC'
Burner (home oil)	2(C'b)
Can Opener	1AC'
Clock (spring operated)	3C''
Clock (electric)	2C''
Drill (hand)	1AC'
Drill (electric hand)	2AC'
Drill Press (electric)	2C'A
Elevator (hand controlled)	2AC'
Elevator (pushbutton operated)	2C'C'
Fire Control (radar)	2(Bb)
Gage (automatic)	2(BC')
Hammer	1A
Lathe (hand lathe motor driven)	2C'A
Lathe (screw cutting)	2C''A
Lathe (old fashioned treadle driven)	1C'A
Milling Machine	2C'A; 2C'C'A
MIT Milling Machine	2(C''b)C'
Molder (automatic)	2C'
Oven (hand controlled)	2A
Oven (clock controlled)	2C'
Oven (thermostatically controlled)	2(C'b)
Oven (product controlled)	2(C'b)
Punch Press (foot operated)	1C'A
Punch Press (motor operated)	2C'A
Punch Press (automatic self fed)	2C'C'
Radio	2A
Record Player	2C''1A
Record Player (coin operated)	2A(C'b)
Radar Gun Layer	2(Bb)
Sander (motor driven)	2AC'
Spinning Wheel (hand operated)	1AC'
Typewriter (hand operated)	1AC'
Typewriter (electric)	2AC'
Typewriter (teletype receiver)	2BC'

THE AUTHORS

Individually and as a team, the authors have been a source of bold and imaginative ideas relating to automation or in their wording—automatism—since the appearance of their prophetic article, "Machines Without Men", *Fortune*, Nov. 1946.

E. W. LEAVER at the present time is president of Electronic Associates Ltd., a company concerned with the design, development, and manufacture of industrial electronic instrumentation. His background in electronics includes experimentation in closed-circuit television networks in the early 1930's, and development of radar and industrial controls.

J. J. BROWN is currently on the staff of the Aluminum Limited Group Co., specializing in the application of automatic data processing to pension, insurance and employee share purchase plans. He is a graduate of the University of Toronto and Yale University. While in charge of technical publications at the Canadian Government's Toronto radar plant he met E. W. Leaver. In addition to collaborating in preparation of articles, the authors have patented a record-controlled machine tool and have submitteed for publication a book dealing with mechanization and automatic control.



STATISTICAL CONTROL SYSTEM

INSPECTS AUTOMATICALLY

Statistics is the science of gathering and interpreting data. Peak performance of statistical control is approached as more and more data can be conveniently gathered and interpreted. In weight control the ideal is available—existing equipment can automatically check weigh 100 per cent of production and statistically interpret the significance of off-weight items

QUALITATIVE inspection of the output of a quantity production machine involves the solution of a paradoxical problem. Quantity production is obtained by speed—but speed is not conducive to quality inspections. Considering weight control, perhaps nowhere is this paradox more apparent or serious than in the food packaging field—involving, as it does, high volume production, low unit values and exacting standards.

In food packaging weight is the concern not only of the manufacturer and his customer but also of the government. You can charge for a pound only when you deliver a full pound. Traditionally, manufacturers have over-filled packages to be absolutely certain that the correct weight of goods is in each package—a potentially costly solution to the problem considering the number of individual packages which a large producer can turn out. How serious overweights can be is indicated by *Fig.* 1. As an example, an average ½-oz overfill in a 1 lb package means that 3.1 per cent of the product packed is given away. The manufacturer is faced with a major problem in keeping overfill to an absolute minimum and still insuring that no underweight packages are produced.

Package Inspection

At filling rates approximating 100 packages per minute, it is obviously impossible to manually check-weigh each package. An early solution to the problem involved spot checking of the packages. An operator would check-weigh every fifteenth package, for example, and from noted trends make adjustments to the filling machine. This enters

Over or Under Wt.		PERCENT LOSS OR GAIN FOR INDICATED NET WEIGHT					
Grams	Ounces	2 oz	4 oz	8 oz	1 lb	2 lb	5 lb
.88	1/32	1.56%	.78%	.39%	.20%	.10%	.04%
1.77	1/16	3.13	1.56	.78	.39	.20	.08
2.66	3/32	4.69	2.34	1.17	.59	.30	.12
3.54	1/8	6.25	3.13	1.56	.78	.39	.15
4.43	5/32	7.81	3.91	1.95	.98	.49	.20
5.32	3/16	9.36	4.69	2.34	1.17	.59	.23
7.09	1/4	12.5	6.25	3.13	1.56	.78	.31
8.86	5/16	15.6	7.81	3.91	1.95	.98	.39
10.63	3/8	18.8	9.37	4.69	2.34	1.17	.46
12.40	7/16	21.9	10.9	5.47	2.73	1.36	.55
14.17	1/2	25.0	12.5	6.25	3.13	1.56	.63
17.72	5/8	31.3	15.6	7.81	3.91	1.95	.78
21.26	3/4	37.5	18.8	9.37	4.69	2.34	.94
24.81	7/8	43.8	21.9	10.9	5.47	2.73	1.09
28.35	1	50.0	25.0	12.5	6.25	3.13	1.25

Fig. 1—Chart of percentage value of fractional gram or ounce loss or gain on packages of various weights. Importance of even small losses in quantity production runs is readily apparent

into the realm of statistics; complete success of spot checking revolves around how representative an individual specimen is. Variation between weights of consecutive packages does occur in food packaging just as in other industries; it is a function of many things including the product, operating characteristics of the filling machine and control settings of the filling machine. As an example of the variations consider *Fig.* 2 which is a graph of the weight of 100 consecutive cookie packages; the operation was running at 100 packages per minute. Only nine packages are exact weight and one-half of the total are heavy by ½-oz or more. Note the distorted statistical picture which would be given by spot checking every fifteenth package and the difficulty an operator would have in interpreting the data as a guide for control adjustment.

For processes similar to this cookie packaging, various manufacturers have introduced weighing equipment to replace spot checking type of control. One item, the Selectrol manufactured by the Exact Weight Scale Co., has been available for a number of years, *Fig.* 3. This device is capable of separating packages on a moving line into an over, under and correct weight category by automatically check weighing each package or production unit against a desired standard.

Up to 100 weighings per minute can be made, depending of course on size and weight of each unit being classified. Rejection accuracy of 0.2 per cent of weight of the commodity at maximum conveyor speed is possible. Range is adjustable to users requirements. Basis of rejection is altered frequency of a vacuum tube oscillator; the variations in this signal are measured by a receiver element which works through a relay circuit to actuate deflection of over-under reject gates. Correct weight packages proceed by conveyor to a closure operation and the only items requiring handling are rejects which can be trimmed manually at some convenient time. By observing quantity of rejects and knowing weight variation, filling ma-

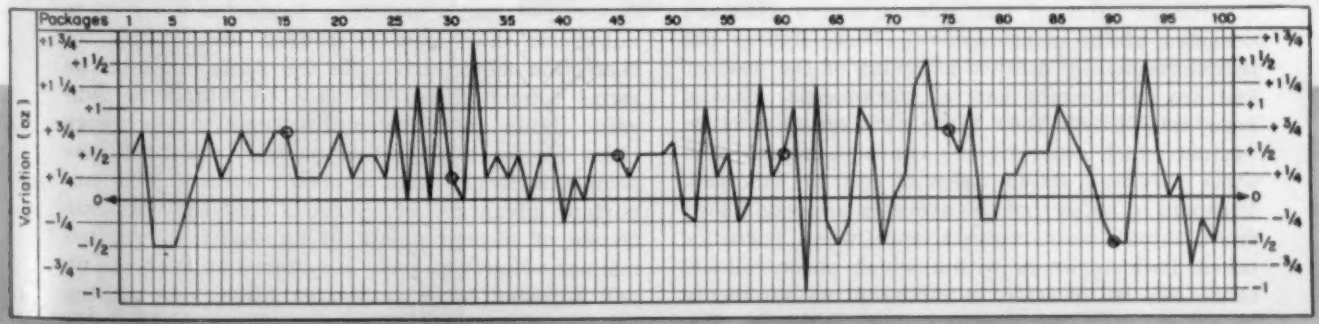


Fig. 2—Graph of 1 lb cookie packing operation, running at 100 packages per minute. Problem in statistical control is to separate chance and assignable causes of these apparently erratic variations in weights of consecutive packages

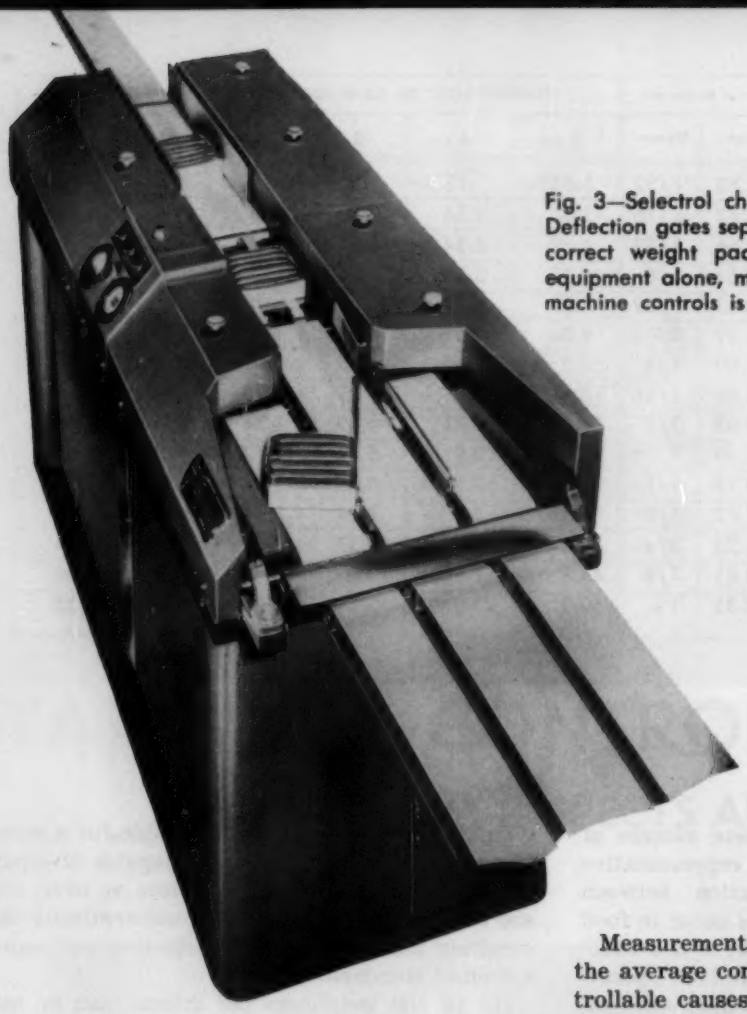


Fig. 3—Selectrol check weighs each package. Deflection gates separate over and under from correct weight packages. With use of this equipment alone, manual adjustment of filling machine controls is necessary

chine operator has information which can guide him in adjusting the controls, *Fig.* 4.

▶ Control System

Engineering a complete system of control by utilizing the mass of potentially useful information which a Selectrol can provide was a next logical development. Statistical methods must be resorted to in interpreting the information since, as it has been shown, classification of any one package or item can present a distorted picture of the overall conditions. Use of statistics is based upon experience for any one process which indicates an average qualitative value of the product and a standard deviation of the measurements. These figures can be determined by detailed sampling of the product and are an inherent part of the process. Having been established, they form an average picture against which other figures can be compared and some command action taken if need is indicated. It should be noted that the averages are established from actual measurements and, when correctly taken, indicate limits within which uncontrollable cause can be expected to influence measurements of any given package or group of packages. Redesign of equipment, different products, etc., are typical factors which can change these average figures.

Measurements which exceed established limits of the average condition are assumed to indicate controllable causes of variation and control manipulation or other corrective action is normally called for. Tool wear, variation in pressures, accumulation of waste, and part failure are typical factors which cause measurements to exceed average limits.

Complete control system offered by Exact Weight Scale Co. consists of (1) Selectrol, (2) average and range computer and control indicator, (3) average and range control chart plotter and, (4) control for motor drive on processing machine adjustment.

Average computer element calculates average weight of 10 consecutive packages as they are check weighed by the Selectrol and, simultaneously, the range computer calculates the difference between the maximum weight and minimum weight in the group of 10 packages, *Fig.* 5. Signals from the average computer are compared to statistically determined limits and form basis for a signal to automatic chart plotter, if used, and control for correction motor drive. In the same manner, the range computer can be made to illuminate indicator lights and furnish directions to the range chart plotter if spread of package weight in the sample is larger than a preset normal. One important advantage of charts is that they indicate trends of measurements in an easily interpreted manner. However, once a system has been set up and adjusted for a particular filling process, the charts are not required except when it is desirable to collect recorded data.

The control for the filling or processing machine adjustment drive motor is so arranged that a cor-

rection is made to the filler or processing machine when the average weight of a predetermined number of units exceeds the control limit. The underweight and overweight control limit circuits determine the direction that the drive motor runs. The duration of the time interval during which the drive motor runs can be set dependent upon typical variation and adjustment time for the particular production machine. Large control adjustments are effected by a number of consecutive adjustments, while an occasional adjustment will take care of small process shifts.

Though principally described in application to the problem of check weighing food packages, the system can be used to inspect by weight, solid products such as pistons, hardware, and similar metal or rubber products. Control elements can be applied to many types of processing or manufacturing equipment, as for example milling machines. The application of statistical control to quality inspection is a proved technique in modern quantity production—this particular example of automated statistical control is important in that it points out that this is one proved technique which can logically take its place in more of the automated production lines of the future.

Fig. 4—Over and underweight packages are brought to correct weight by manual filling at special trimming station. Only rejects are manually handled with use of Selectrol automatic check weighing equipment

Fig. 5—System for automatic statistical control includes average and range computer, control indicator and chart plotter. Use of chart plotter is optional but it is important for complete analysis and evaluation of new installations of automatic control systems

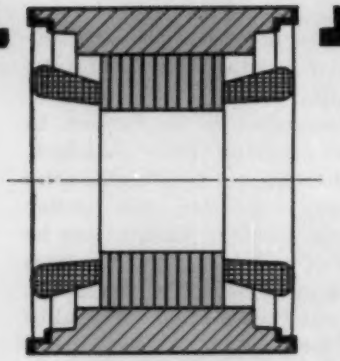


Fig. 1—Both ends of electric motor stator frames are bored and faced simultaneously

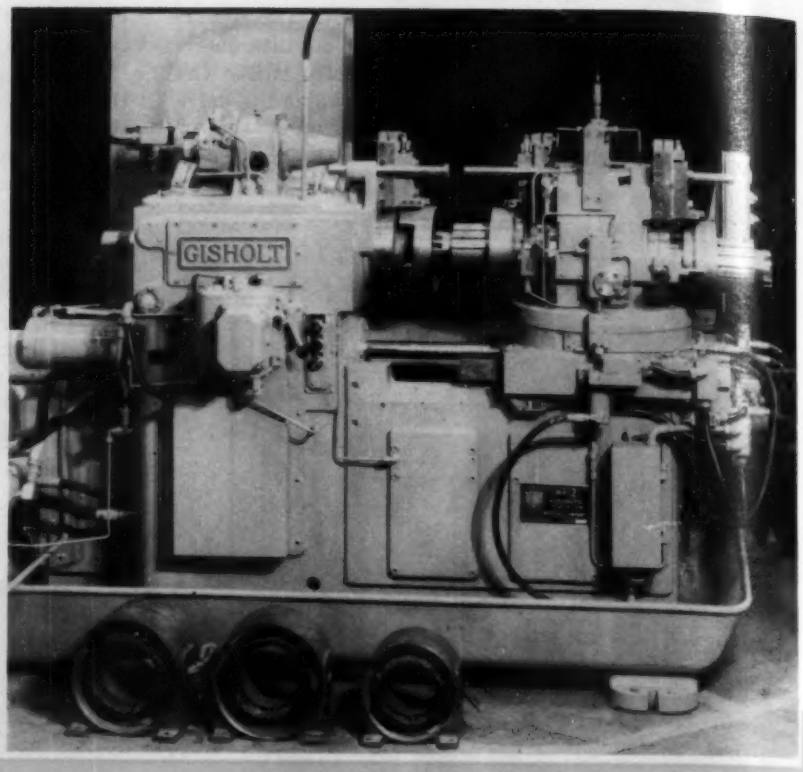


Fig. 2—This standard lathe with special indexing turret automatically cycles to machine motor frames such as the three shown at a rate of 120 per hour

AUTOMATIC CYCLING CUTS MOTOR MANUFACTURING COSTS

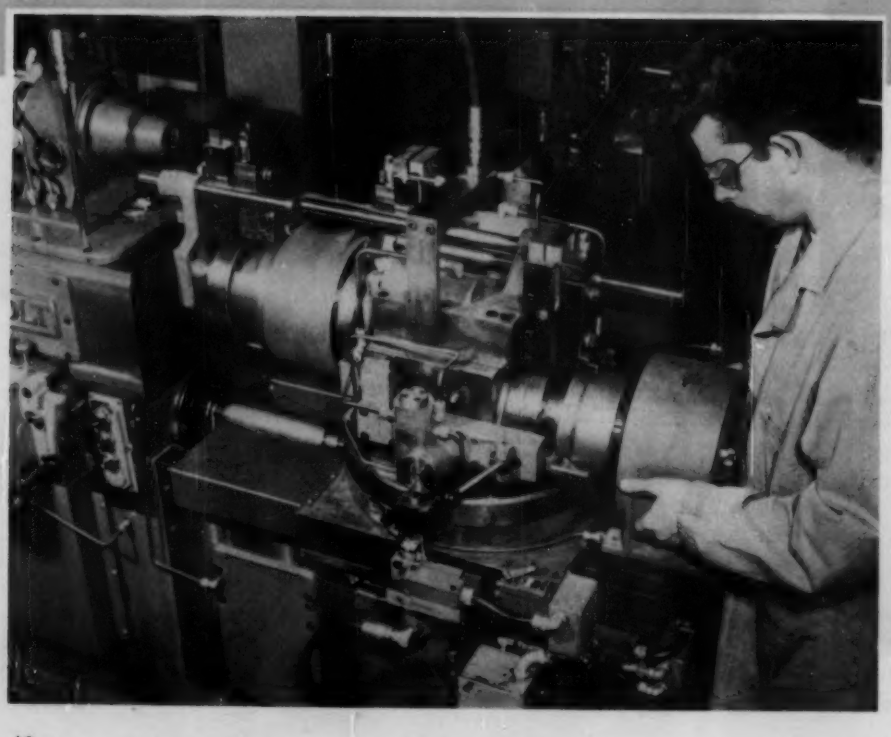


Fig. 3—In loading, the operator slides the workpiece on the contracted mandrel to a locating stop. The hydraulically actuated mandrel is automatically expanded and the operator swings the locator out of the way by moving a handle which also clears the indexing circuit

EFFICIENCY IN PRODUCTION of electric motor frames has been increased by one manufacturer through installation of an automatic cycling lathe that employs twin arbors. The lathe is a standard Gisholt No. 12 automatic lathe with twin mandrels mounted on a special indexing turret. This setup permits loading and unloading operations on one arbor while work is being machined on the other.

Neither the idea of an automatic cycling machine nor of multiple work spindles is novel, however, this equipment is of interest because it demonstrates the application of such well-known ideas to increase the degree of automation in a simple repetitive operation. With the continual demand for higher productivity and lower unit costs, most manufacturers are seeking ways to accomplish this same result.

Both ends of a cast iron electric motor stator frame are bored and faced simultaneously while the workpiece is mounted on an expanding arbor and rotated. Operation time per piece is less than 30 seconds. The areas machined are indicated in the cross-section sketch shown in *Fig.* 1. It is possible to perform this machining either with or without the windings in place, which gives additional flexibility in layout and programming. This same lathe is used to machine a number of different sizes of frames, three of which are shown with the lathe in *Fig.* 2. Changing to different frame sizes requires manual change of arbor expansion sleeves and chip guards and adjustment of tool settings and stops.

In operation, the machine is loaded by an operator who places the rough frame on the idle arbor while another frame is being machined. In loading, *Fig.* 3, the end of the frame is located against a swinging locator containing a limit switch. This switch automatically actuates the hydraulically operated mandrel and chucks the piece. When the part is mounted the operator moves the locator out of the way by means of an operating handle. This action also clears the electrical circuit which actuates the hydraulic indexing of the turret when the machining cycle is completed on the other arbor.

The turret indexes 180 degrees in moving the spindles from the loading station to the machining station and vice versa. Indexing is alternately clockwise and counterclockwise in successive operations, and is automatic; *Fig.* 4 illustrates the turret during indexing. When the loaded mandrel has been indexed to the proper point the turret carriage traverses toward the lathe headstock. Carriage travel is approximately 5 inches. A lock bolt clamps the indexing plate down on the carriage and the forward movement of the carriage engages the teeth on the mandrel with the driver on the lathe spindle nose. The electric clutch is automatically engaged and the spindle begins to rotate as the carriage continues to move forward.

One end of the stator frame is bored and faced by a form tool in a holder mounted on the headstock, and the opposite end is bored and faced by a form tool in a sliding holder carried on the indexing unit. Each mandrel on the turret has an associated sliding tool holder but there is only one tool holder on the headstock. The tool carried by the sliding holder on the turret is mechanically fed into the work during the forward motion of the carriage. A pusher rod on the carriage meets a stop on the headstock and slides the tool holder forward and the tool into the work by means of a simple rocker arm. The forward motion of the carriage also feeds the work into the tool mounted on the headstock.

Chip guards protect the mandrel and also keep chips out of the windings or winding slots. Air streams are directed at the tools and provide cooling as well as blowing chips out of the machining area. When the sliding tool holder and the turret carriage have fed to dead stops, the spindle is stopped by an electric brake and the carriage travel is reversed. At this same time the tools are moved out of contact with the work. During reverse traverse the lock bolt is automatically loosened so that the turret may be indexed, and the sliding tool holder is returned to its starting position. The mandrel is contracted, and the machined frame can be removed and the mandrel reloaded for a new cycle.

In addition to the switches needed to start and stop the machine for automatic cycling, the electric circuit used provides over-riding manual controls for indexing and reverse traversing. This provision for manual control is important to facilitate setting-up operations.

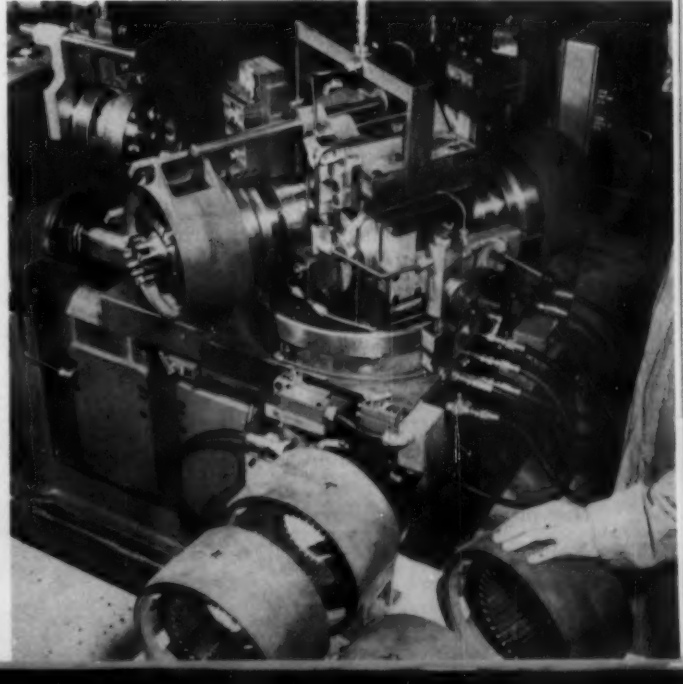


Fig. 4—After the cutting operations are completed the turret is indexed automatically by hydraulic means with the rough frame moving to the cutting position and the machined piece to the unloading position

Assembly by automatic machines requires solution of engineering problems both in the design of the mechanisms that perform the operations and in the design of the product for ease of assembly if downtime is to be kept to a minimum

Part 3

DESIGN CONSIDERATIONS FOR AUTOMATIC ASSEMBLY

By **GEORGE H. KENDALL** and **JERRY A. HOST**
Consulting Mechanical Engineers
Darien, Conn.

DESIGN PROBLEMS encountered in conjunction with assembly machines are as varied as the scope of operations normally performed. Positioning workpieces together and securing them into required assemblies may involve attachments designed for pressing, clamping, spinning, flaring, crimping, riveting, nut setting, screw driving, glueing, welding, brazing, or soldering. The application of heat by ovens or induction units may be necessary for the purposes of drying, aging, curing, soaking, or fusing. Cooling by water or freezing units may be required.

To make the most of the potentials offered by assembly machines one must not overlook the opportunity to combine with the routine assembly operations such items as coding, printing, labeling, testing, coating, weighing and packaging. Broad use of assembly machines as precision inspection equipment is readily practical for the continuous sorting of *Accept* and *Reject* parts wherein four to eight dimensions are checked on the machine at one time and follow or precede assembly as required.

Although it is possible to include machining operations in the sequence of assembly operations, the problems of removal of chips, coolant, dust, and dirt that are involved in metal cutting make this practice detrimental to automatic assembly. As a result most assembly machines are not designed with the facilities for coolant pumping, chip removal, and workpiece degreasing that are essential to extensive machining.

Downtime and Its Effects

With the availability of more than one hundred different types of tooling attachments for assembly operations, the broad nature of the subject becomes evident. The probability factor of downtime to influence operating efficiency assumes vital importance.

It is evident that if we are in volume production assembly of a product having say 100 parts, comprising 12 mechanisms, with two semifinal assemblies and one final assembly, that we will have a very great number of points of sensitivity. If in this case the assembly production is continuous with only one minute downtime per sensitive item or per sensitive station per day, there might be a great number of minutes lost. One-hundred items of one minute each out of a possible 480

production minutes per day would represent a major dent in production results. The chances are also that such downtime, the individual items of which may occur only once in a day of say 20,000 assemblies, will be for more than one minute; or even more than five minutes. As these minor stoppages rarely occur at the same moment in any continuous production process, the total effect of the sum may seriously alter the anticipated production yield.

It takes very little of this, in what would otherwise be a successful process, to reduce efficient productive time to 25 per cent, or even 15 or 10 per cent—as many know to their sorrow—with downtime up to 85 per cent.

Consider for example, a modern shop mass-production record, where daily rejections for all causes on a volume-produced part may range from 0.2 per cent up to 1.5 per cent. When applied to machine assembly averaging production at 20,000 per day we have a range of anywhere from forty to three hundred downtimes if the item has a tendency toward supersensitiveness to trouble in assembly. It is apparent that wherever particular parts are shown to be sensitive in normal production it is vital that proper controls be set up to eliminate them.

We believe it is vital, therefore, in any complete assembly process for successful production, to provide those essentials that will assure full control of downtime. To illustrate: if a process has 100 steps; break up the equipment so that each unit will handle about eight to twelve steps, and place parts-in-process reservoirs between these units with automatic feed and delivery. In this way the downtime of any one unit does not affect the entire production, but only the one unit involved. The others continue to run, drawing from the reservoir following the down machine. Those units located prior to the unit down, feed into the reservoir ahead of the down unit. When the down unit is again started, if of variable speed type, its rate of production may be speeded up slightly above the rate of the whole line until it has caught up all losses. The excess replenishes the reservoir of the down unit until the production line is again in balance.

The use of standard general-purpose type assembly machines make such a practical approach possible. This is basically the common policy followed for many years with multiple spindle lathes and similar high production equipment.

Assuming that the automatic machinery used is fully capable of a rigid degree of production uniformity without faulty elements or controls; those items most likely to cause downtime may be generally classed as follows:

1. Parts dimensionally off tolerance limits.
2. Parts not having clear cut orientation marks.
3. Parts tending to nest and cling together.
4. Parts not holding their own fixed shape.
5. Parts of difficult design requiring compound assembly motions to move and orient.
6. Lack of operator attention at the machine.

Courtesy, Revere Copper & Brass Inc.

Fig. 14—Products such as this handle required in large volume production, having no easy orientation register points, call upon the inventive skill of the machine attachment designer. Assembly machines must be provided with a wide variety of feeding, orientation, tracking, escapement, and positioning attachments to handle anything that may be required of the machine

TYPICAL SEQUENCE TOOLING FOR STANDARD CONRAD TYPE ASSEMBLY OF BEARING

(30 to 50 per minute)

Rivet or Bent Tab Type Retainer Assembly (8 Balls)

Station #1—Feed and orient "Half Retainer" into position at work station nest

Index Station #2—Hand feed and orient "Bearing Rings" and "Balls" (properly spaced) assembly onto the "Half Retainer" position at the work station nest

Index Station #3—Feed and orient "Other Half Retainer" onto Bearing with pilot for rivet hole alignment at work station nest

Index Station #4—Feed four "Rivets" into position at work station nest

Index Station #5—(Same)

Index Station #6—Power head over "Rivets" to complete assembly at work station nest (NOTE: Or crimp tabs if tab type)

Index Station #7—Deliver to chute, tray or container as customer may prefer

Index

Fig. 13—Automatic assembly of the common ball bearing has always been a very interesting problem. The particular sequence of operations shown here has bearing rings and balls fed as preassembled units but other tooling arrangements are capable of adding rings, putting the balls in place and evenly spacing them for the retainers. Dust plates, shields, and seals can also be added to the assembly

▶ Assembly Machine Design

Influence of operating personnel on downtime was discussed in Part 2, yet those factors and the points just mentioned presuppose accurate and reliable functioning of the assembly machine. Achievement of this accomplishment is a large responsibility of the designer of such machinery. To design, on paper, mechanisms which will perform the desired operations with a minimum of puttering, cutting, and fitting to make them work is an art. Involved is a lifetime of study by professional engineers of widest practice, acquiring the basic knowledge, accumulating experience, and applying this know-how in an approach to assure sound and practical results.

The art of feeding, orientation, tracking, escapement, positioning, and split-second sequence time control reflects complex mechanical and electrical problems that must have the closest degree of engineering balance to assure success.

The first problem, **feeding,** involves thorough study of the type of feeder or magazine to be used to handle the parts as brought to the machine. Here the nature of the part has the controlling influence; is the material hard or soft, magnetic or nonmagnetic; is the shape such that in bulk the parts will nest or cling together in a nonseparable fashion; is the structure or finish fragile so as to preclude bulk handling? Many variations of proven feeding principles have been designed to handle specially difficult parts.

The second problem, **orientation,** requires that the workpiece be fed to the machine with the proper side up, correct end leading, or the chosen points of zero register in the desired location. Unless the mechanisms perform this function positively every time there can be no successful operation.

The third problem, **tracking,** has to do with maintaining the parts in their oriented position as they are transported to the assembly station. Part of this problem is also to see that a quantity of parts is always ready for delivery to the point of assembly.

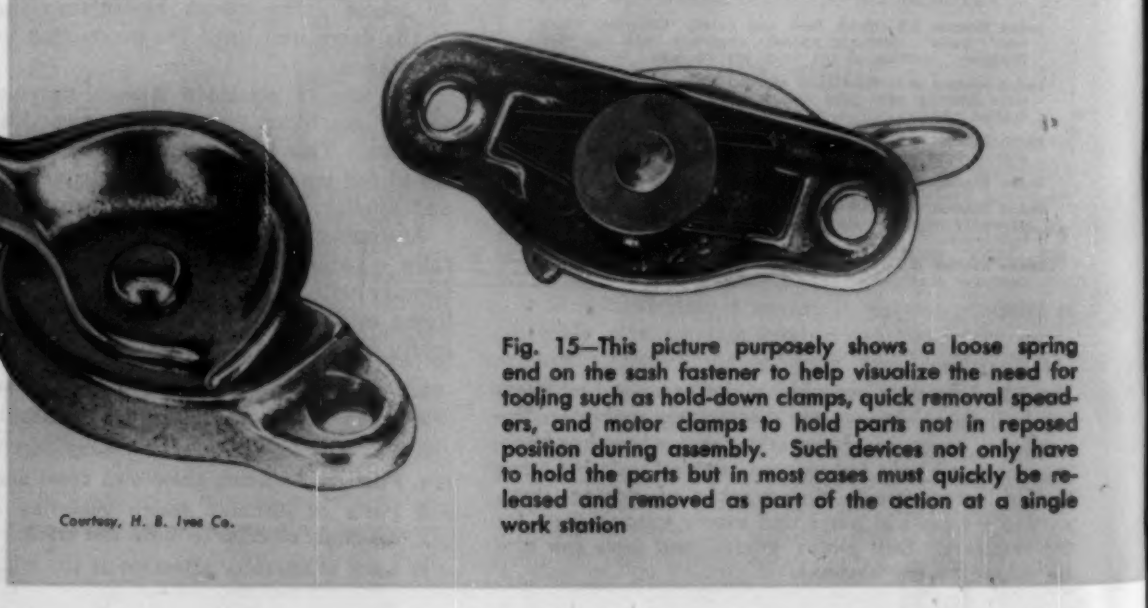
The fourth problem, **escapement,** refers to the means of retaining the oriented parts at the work station and delivering them one at a time into the work nest. This may involve pushing the parts against a register positioning stop and actuating the workpiece with fingers or pawls. Actuation of this escapement mechanism must be accurately timed with the machine operation.

The fifth problem, **positioning,** necessitates that a positive action deliver the part just released from the escapement mechanism, and seat it properly in the work station.

The sixth problem, **timing,** is perhaps the most difficult and complex issue that faces the assembly machine designer. Not only must each action at a given station be controlled, but assurance must be provided that every sequence is actuated at the right split second in relative timing with other stations of the machine. By judicious use of mechanical linkages, cams, electrical limit switches, and other standard hydraulic and pneumatic control device an interlocking control system is devised.

Basic controls for an assembly machine that is to remain fully flexible for resetup of other tooling to perform a different sequence of operations must provide a high degree of flexibility in the timing arrangements. Full utilization of the potentials of the general purpose machine is possible only if the new control sequencing arrangement can be made quickly available when the tooling is mounted on the machine. Control systems that use tapes to actuate the sequence circuitry provide for job changeover by replacing the tape.

A preferable system includes a sequence timer connected to a program board of contacts which



Courtesy, H. B. Ives Co.

Fig. 15—This picture purposely shows a loose spring end on the sash fastener to help visualize the need for tooling such as hold-down clamps, quick removal spreaders, and motor clamps to hold parts not in reposed position during assembly. Such devices not only have to hold the parts but in most cases must quickly be released and removed as part of the action at a single work station

uses a wiring template, cut for each job. This provides the added ability to adjust the timing of individual circuits by "advancing or retarding of the spark" without having to remake the entire control media. Such a feature is extremely desirable because duplicate tooling components do not always perform exactly at the same speed of actuation, such as air cylinders for example. By this method one station circuit can be adjusted relative to another without altering the sequence.

The control system is of importance from another point of view. As part of the basic design of the assembly machine it places limitations on the scope of the machine's operations which will reflect in each job subsequently run on this machine. Therefore in addition to needing a system that is initially sound, the designer that plans and executes future tooling arrangements must fully understand the system's capabilities and limitations.

▶ Design of Product Components

Designing for volume production years ago, long before the word "automation" had been used, consisted of about 80 per cent technical common sense and 20 per cent practical know-how. Design of a machine tool was considered the highest degree of quality engineering and the design of a motor car a pinnacle of engineering for volume production. The basic skills of years of experience and shop training in these fields produce by far the best machine design engineers. With the coming of the automation period, following a generation of building of continuous automatic machinery, the need for design engineers basically skilled in these arts assumes greatly increased importance.

Designing for automatic assembly for sound and practical trouble-free daily production calls for all the design skill available to assure that every part of a mechanism goes together easily and directly without complicated or compound movements.

Proper design for assembly belongs in the fore in any serious consideration and analysis by a company for an assembly machine department. National Defense Authorities in charge of major programs should stress the vital importance of these facts as they are the actual key toward getting into mass production quickly in event of any war need. Design analysis and building of pilot tooling will prove and check these essentials and have them properly prepared and ready whenever needed.

Assembly machines with their full automatic handling of many parts, require that each and every part that is to be positioned in a certain direction or location within an assembly must have a point or surface of register to enable positive orientation all the time. To illustrate: Parts such as a number of small gears that vary one tooth for different position location in instruments, need clear-cut identification marking. Springs of compression type where the coils are open or of open-end design, bent wire parts, fasteners that tend to nest together are always troublesome, requiring special feeder handling throughout. Electrical coils where the fine terminal wires are loose, wavy and too small to hold their own shape, or are easily bent, contribute to tooling difficulties. Odd shaped parts with no surfaces of register or location contribute to more elaborate tooling fixtures for a rigid degree of uniformity of production handling.

Parts that do not separate quickly and tend to cling together when placed in bulk containers, are not considered as having good design for automatic assembly. While all of these more difficult parts can be effectively handled by proper assembly machine tool and fixture design, it should be clear that they cause greatly increased tooling costs and become the supersensitive variables of daily downtime loss of production. Product redesign is normally indicated under these conditions before setting up for automatic assembly. Winding of small wire coils on cores for electronic and electric parts is particularly in need of the design engineers attention for simple fast handling. There is no reason why 24 operations should be used on a simple core and coil when nine operations would be considered ample if the design were altered for automatic assembly. Often this one change on a volume-production application will save enough within

TYPICAL SEQUENCE TOOLING FOR COMMON WINDOW-TYPE SASH FASTENER

(30 to 50 per minute)

Station #1—Hopper feed "Fulcrum Pin Rivet" into station nest at lower level

Index Station #2—Magazine feed "Lever" onto rivet at station nest at lower level

Index Station #3—Magazine feed "Body" at upper level at station nest

Index Station #4—Magazine "U" shape "Spring" into "Body" at upper level station nest

Index Station #5—Spreader tool for "Spring" spreads "Spring" and holds at right angles in proper relation position at station nest from center turret

Index Station #6—Lower station nest raises the "Rivet" and Lever to assembled position at upper level station nest at relative position with "Body" with hold down clamps in position

Index Station #7—Withdraw spreader tool

Index Station #8—Hopper feed "Washer" into "Rivet" at station nest

Index Station #9—Rivet, or head over, for final assembly to the proper stops for right play within parts

Index Station #10—Deliver to chute or container as preferred

Index

Fig. 16—Here is how the window sash fastener such as illustrated in *Fig.* 15 might be automatically assembled "as is", without product redesign. Note the work nest would have a lower movable level to raise and lower parts at the right time of station indexing. Also note the use of a spreader tool to hold the two springs apart for the assembly of other parts

TYPICAL SEQUENCE TOOLING FOR MOTOR FIELD RINGS

(30 to 50 per minute)

Station #1—Magazine feed and orient one "Field Segment" into location at work station nest

Index Station #2—Magazine feed and orient one "Field Segment" into location at other half position at work station nest

Index Station #3—Feed and orient for burrs one "Shading Ring" into position at work station nest and press down

Index Station #4—Feed and orient for burrs one "Shading Ring" into position over other ring at work station nest and press down

Index Station #5—Power press down to final position and stack at all locations at work station nest

Index

Fig. 17—Motor field ring assembly is an example of one of the thousands of electrical and electronic products that can be effectively and practically assembled by machines

a year to pay for an entire assembly machine installation.

▶ Design of Complete Product

Design for automatic assembly provides sets of parts that have rigid dimensional tolerance control established on all dimensions where parts come together in close fits. These parts should drop into place easily one within another and at the proper location in the assembly so that fasteners of all kinds will also drop or can be pushed into position at uniform pressures.

Assemblies that specify welding, brazing, s- dering or other fusion or cementing of parts r- quire orienting of the parts so that they regist- accurately when pressed together. Orientation d- mands that parts have some positive accura- means of register identification so that they ca- by automatic means be located one with anothe- Machined surfaces, holes, notches, slots, keys, an- shouldered shafts illustrate some of the mean- commonly in use.

Where several mechanisms are to be subassembled, one on each machine, and the subassemblies handled on the final machine, it is of particular importance that basic register points be clearly and positively established on each subassembly to tie in accurately with the other mechanisms at final assembly. Otherwise minute errors multiply until trouble develops. It can be understood that where ten to twenty parts are assembled and if each is off only 0.001-inch, the sum could total 0.020-inch, but if definite register points were established on the one part that tied in with all others the error could still be only 0.001-inch.

The accumulation of tolerances in assembling successive parts is of concern to the design engineer no matter by what method the parts are to be assembled. The designer must be aware, however, that whereas a skilled mechanic might detect this accumulation as he hand assembles the product; the machine performing this same assembly operation might jam because this tolerance buildup was overlooked.

The design engineer, if granted time for proper study of assembly machines, needs to apply only "hard-boiled" common sense in order to specify designs in a manner that the parts can be readily put together. It is relatively just as easy for a competent designer, schooled in these basic principles, to design all parts practically so they may be handled easily as it is for one not aware of such considerations to design needless complications into the assembly problem.

INSPECTS AND CLASSIFIES BEARINGS AUTOMATICALLY

AUTOMATIC, hopper-fed electronic gage, which measures the OD of precision bearing balls, ¼-inch to 17/32-inch, and sorts them into 12 good classifications of .00001 inch each plus oversize and undersize has been developed by Federal Products Corp. The operating speed is adjustable to sort up to 24,000 bearing balls per hour. The gage is completely automatic. The operator fills the hopper and presses the start button. From a rotary type hopper the balls drop into one of eight holes in a rotating index wheel. At the proper time sequence, determined by timing limit switches, a sensitive contact is lowered to the ball OD and the size is found by an electronic gage head. An electronic impulse is transmitted to the correct OD size station in the classifier which causes a mechanical memory to be set. The index wheel transfers the ball to a large wheel which carries it around to the correct size disposal chute which is opened by action of the mechanical memory and the ball drops into an oil-filled tote box beneath the gage front.

Fig. 1—Automatic Graphotype machine used to emboss metal plates with production and identification data. Blanks are loaded in the upper left-hand hopper and embossed plates unloaded from the rack just above the vertical reel. Information is transferred from common language tape to the metal plates

By P. B. GARROTT
Director of Market Development
Standard Register Co.
Dayton, Ohio

TYING PAPERWORK TO PRODUCTION

FOR AUTOMATIC DATA PROCESSING

Factory paperwork is vulnerable in two respects—it is abhorred by production people and it cannot stand rough physical treatment. The automatically embossed plate protects factory data from both antagonists—human error and environmental mutilation

INTEGRATED data processing was introduced as an element of automation in a series of three articles beginning last December. These articles discussed the paperwork problem, how and why integrated data procesing can solve the problem, and finally, how to approach an individual problem with the integrated data processing tool.

After this basic outline of the method for automating office paperwork, it follows that there must also be some form of direct tie-in with the production line to complete the loop. The case histories to be presented in this and succeeding articles serve this purpose with respect to integrated data processing. Each contains a typical problem to be found in the production end of business operations and relates integrated data processing to the relief of that problem and to synchronizing the speed of data handling for manufacture with the speed of production operations.

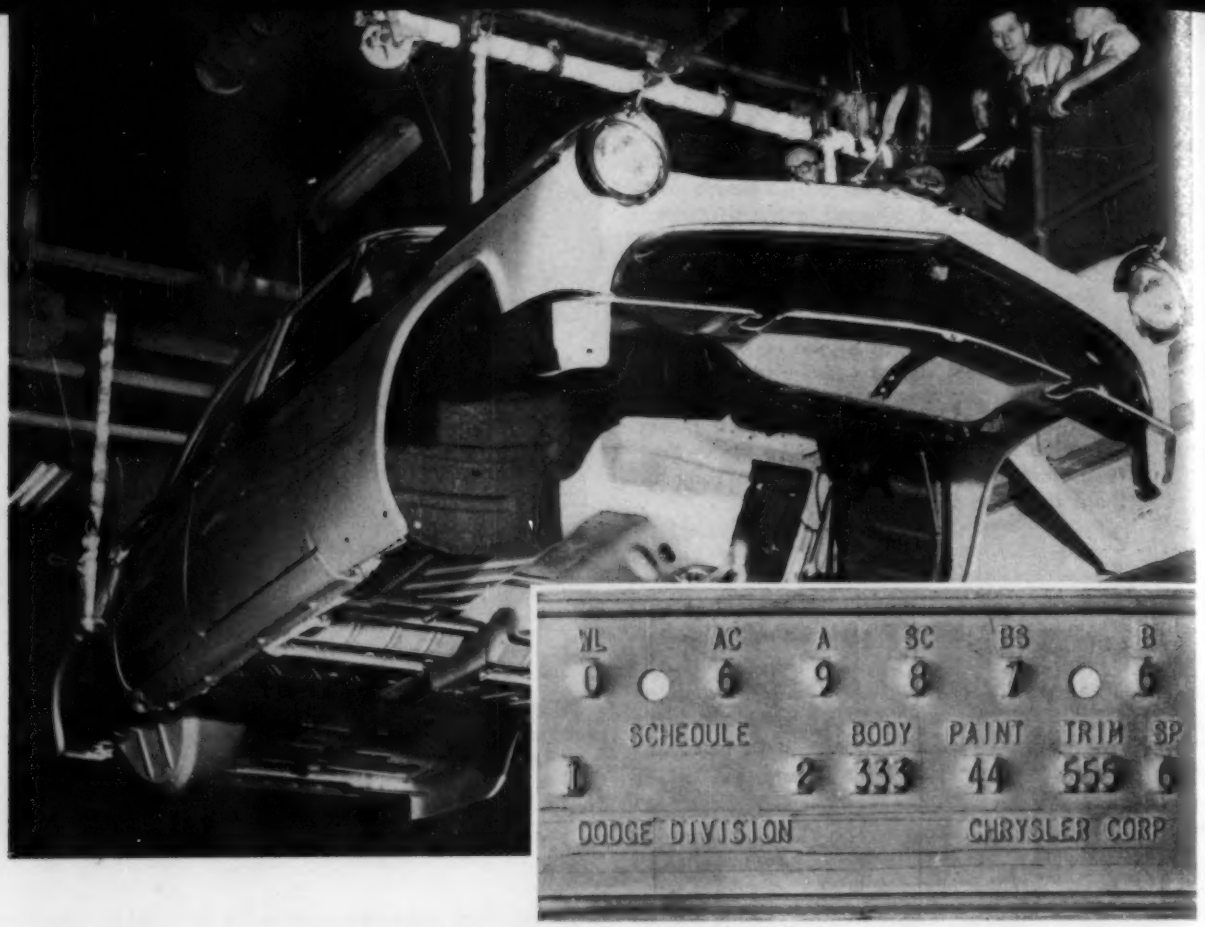


Fig. 2—Embossed metal plate used in the Dodge Div. of Chrysler Corp. as a permanent identification record. Advantages over paper records are obvious

▸ Embossed Plates or Tags

Paper records of one kind or another are the conventional medium upon which data is recorded. For most business purposes, a piece of paper is well suited to the data carrying job, but in certain other cases a piece of paper doesn't stand the proverbial snowball's chance of surviving.

As an example of one of those special circumstances, consider the data which must accompany an auto body through various production operations. Each body must carry its own individual identification, including serial numbers, style and color codes, and other such data through such rugged processes as welding, bonderizing, and spray painting.

It's unreasonable to expect a piece of paper to come out of any such treatment still bearing legible information, so some more durable recording media must be used. Then, too, the means of recording must be such that the data will remain clearly legible through pickling baths; past welding torches, and under several coats of paint, where necessary.

The embossed metal plate meets those tests, and many others, hence is a data-bearing record suitable for use in many situations in which more conventional records could not be used. Wherever material must be identified in some manner which will defy weather, heat, chemical action, or "painting-over", the embossed plate or tag is likely to be found in use.

This article will be devoted to suggestions and explanations of the manner in which integrated data processing may simplify the preparation of such plates. Production men who are now using embossed identification records may find that these ideas will provide lower costs and fewer errors when applied to existing operations. Others, who may have been barred from the use of embossed plates or tags by the cost of conventional manual embossing, may find that the more automated approach will justify a re-evaluation of the idea.

▸ Paperwork in Overalls

Preparation of embossed tags or plates is really a clerical job, even though it is done by a horny-fisted six-footer in greasy overalls. To that clerical job, integrated data processing can bring greater accuracy and speed and lower costs than can be had by manual embossing methods.

In most cases, the figures and characters to be embossed upon these metal strips will first be

typed upon a piece of paper by some other worker. In other words, the fellows who make and attach identification plates do not select numbers at random, but take the proper data from some typed or written document. It is toward that conventional document that we should look first, keeping in mind the general integrated data processing theme. If that earlier document can be written by equipment which also produces punched paper tape, then the same tape may help to mechanize the embossing job.

That's exactly what happens in the plant of a major auto manufacturer. A set of forms is typed in advance of the assembly of each car. Information being typed on that document may be for the particular benefit of the dealer who is to receive the finished car. Certain portions of that information, such as body serial numbers, style and trim codes, will also become the permanent embossed identity of that body when the car has been built.

Here, then, is an obvious case of data which is repetitive in nature—needed in typewritten form for one purpose and in embossed form for another. If there's anything to this integrated data processing, then this should be a made to order chance to use it—and it is.

Preparation of the typed document, in this case, is by means of a tape-punching typewriter. The form is typewritten about as it would be done by any typist. The big difference lies in the fact that the girl who types that form might also be said to be making the embossed plate for that car at the same time. In all probability, that typist will never see or touch either the identity plate or the car body involved. Nevertheless, the keystrokes she uses to put data upon that set of papers will put the embossed characters upon the metal plate, automatically.

This double-action data recording is made possible by the fact that, as information is typed upon the form, it is also punched into a strip of common language tape. That tape is taken to the point where body identification plates are needed. The correct plate for each body is embossed quickly, accurately, and automatically by an Automatic Graphotype, *Fig.* 1, operated and controlled by that piece of paper tape.

An earlier article (See AUTOMATION, Dec. 1954) referred rather briefly to the Automatic Graphotype as a member of the family of common language machines. That reference was to the standard model of this device, which is usually used to emboss metal plates employed in the Addressograph addressing process. These addressing plates generally have characters about the same size and style as conventional typewritten characters, and are well-suited to the uses for which they are intended.

Industrial identification jobs, such as car-body plates, may require sizes or styles of embossed characters considerably larger than typwriter type. To meet such special requirements, the Addressograph-Multigraph Corporation, manufacturers of the Automatic Graphotype, have developed special embossing dies capable of making relatively big, bold characters, *Fig.* 2. Data embossed in suitable metal plates or tags, in big, readily-read characters like these, can do an outstanding job of identification in those cases where permanence, weather-resistance, or other such characteristics are needed.

It should be noted, in passing, that the car manufacturer using this process has received considerable earlier recognition for developments in engine-building automation. While engine-building automation may be bigger and more spectacular, this company found it worthwhile to refine, mechanize, and improve the production of even the humble identity plate, *Fig.* 3.

Auto manufacturers are not, by any means, the only ones who need and use metal identification

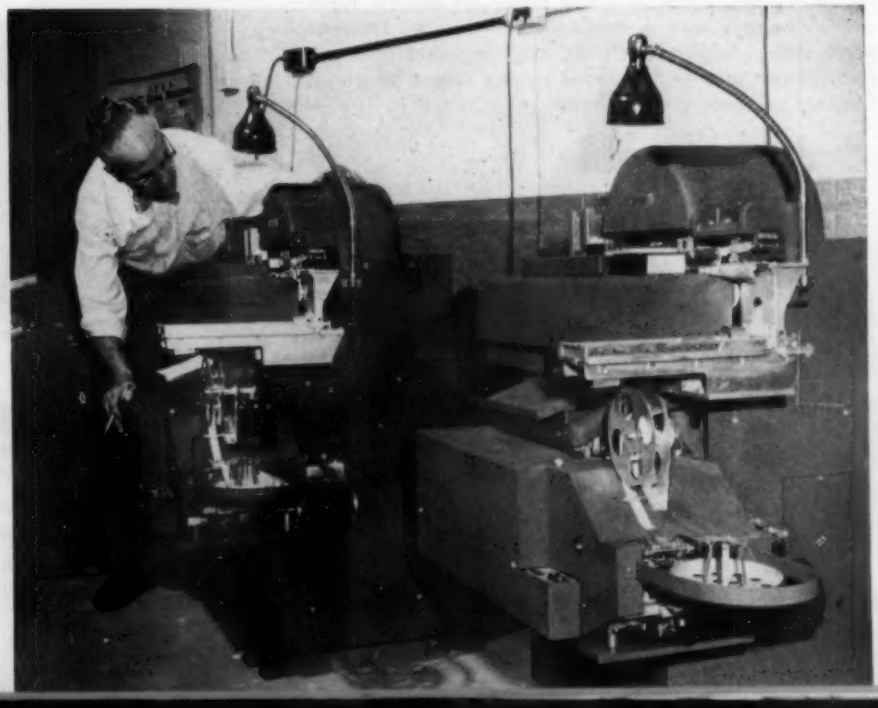


Fig. 3—Body building information is transferred from IBM cards to common language tape and then stamped into metal plates by the Graphotype machine. Plates are attached to each car body on the body assembly line

records. Embossed strips may be found nailed to most utility poles; riveted to electric motors; wired to bundles of poultry fencing.

Another specific example of this type exists in the mills of one of the most famous names in copper wire and cable. Details are similar, in many respects, to the one cited previously. A piece of common language tape is the by-product of typing a document needed for other production work anyway. The tape then operates an Automatic Graphotype producing metal plates which are attached to those huge reels of wire or cable.

Additional examples might be cited, but the basic pattern is similar in most such cases. For that reason, the remaining space will be devoted to comments and suggestions intended to implement efforts to evaluate this aspect of integrated data processing.

▶ New Ideas and Equipment

One interesting sidelight concerns a recent development which may make empossed plastic strips or plates available. A plastic capable of being cold-embossed has been demonstrated. The reported characteristics of this plastic sheet make it appear to be suitable for substitution for metal in many cases. Embossed samples display good stability and retain data in satisfactory form even after rough treatment. Such a development might make this aspect of integrated data processing even more attractive. One result might be an appreciable reduction in plate cost. There can be no doubt that factors of reduced weight and lack of electrical conductivity may favor plastic material in some cases.

Another aspect of this overall idea is concerned with the method used in producing those common language tapes which are needed to operate embossing equipment. Earlier reference has been made to tape-reading and tape-punching typewriters. The one such unit presently available is a rather expensive piece of equipment as contrasted to an ordinary typewriter. Obviously, such a device justifies its cost when all its special abilities are needed and used.

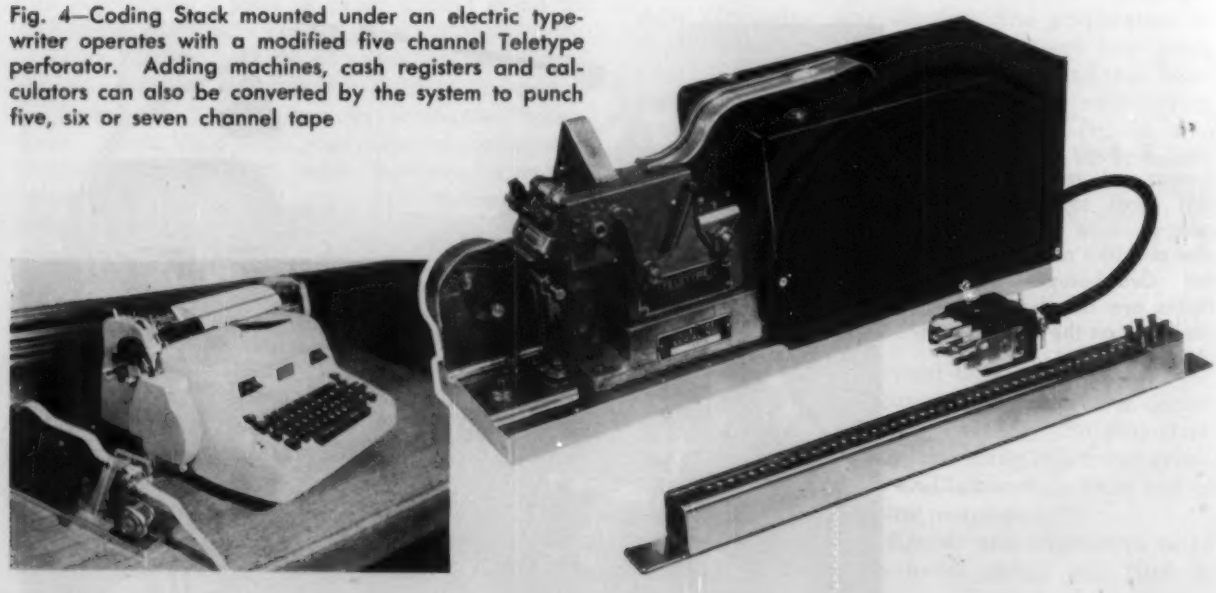
For the simple tape-punching jobs in these examples, however, use of a fully equipped tape-reading-and-punching typewriter might constitute overtooling. Further, the expense of equipping for the job in this way might, in some cases, be greater than the benefit expected.

Those who need tape producing ability alone, and do not require that the tape be read by the same machine, should investigate the simple Coding Stack, *Fig.* 4. It is a device which can convert any typewriter and many other key-operated machines into tape-punching machines as well. The device is a rectangular bar bearing electrical contact points along its top side. Attached beneath the key-lift levers of a typewriter, it converts each keystroke into a predetermined electrical code pulse. Those pulses, in turn, may be wired to a separate tape-punching unit, causing each typed character to be punched, in common-language code, into a strip of paper tape.

Resulting tape, punched with the five-channel communications code, is capable of operating any of the common language machines having tape-reading abilities. Thus, this device, produced by the Telequipment Corp., qualifies as another full-fledged and potentially useful member of the common language machines family. It is significant, too, that any typewriter can be converted to make by-product tapes by this means.

Examples mentioned here bring integrated data processing closer to production men by presenting it as a practical production tool. In subsequent articles, it will be related to other common plant and mill operations.

Fig. 4—Coding Stack mounted under an electric typewriter operates with a modified five channel Teletype perforator. Adding machines, cash registers and calculators can also be converted by the system to punch five, six or seven channel tape



SMALL PARTS HANDLING CAN BE CRITICAL

By E. A. CARNEY
The Chas. Wm. Doepke Mfg. Co. Inc.
Rossmoyne, Ohio

Receipt of hardware and component parts at the plant leads to the question of how best to handle and distribute these items to various usage and storage points. Quantity consumption of small parts by the modern automated plant accentuates the need for a simple procedure if optimum plant efficiency is to be maintained

MANAGEMENT interest in automation is created by real and powerful pressures. Consumer demand for improved quality, price competition, expanding markets and increased diversity of products are creating serious problems—problems involving the control of manufacturing costs, the necessity of maintaining balanced production and the achievement of uniform and controlled quality.

Large industries have directed their efforts to developing automation in an efficient blending of men, materials and machines to achieve the maximum in quality production. It is paradoxical that one of the effects of automation on some small and medium sized manufacturers has been the adoption of a "do-nothing-at-the-present-time" attitude, because where and how to begin are critical questions to be answered. There are, however, things which can be done today which can aid in the development of an atmosphere more conducive to automation. Since the maximum achievement in automatic manufacturing processes by any manufacturer would be minimized by his neglect in bringing his housekeeping standards up to a maximum point of efficiency, it follows that control of plant

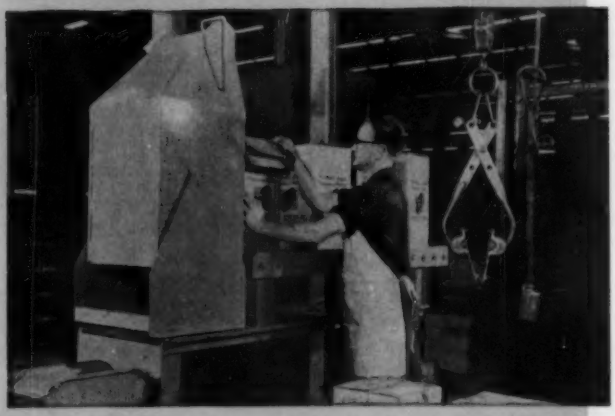


Fig. 1—Bulk packages of small parts are directed to central area. Carton is raised into position using a lightweight hoist and is rolled into the counter balanced dumper. The fixture is turned to filling position; the filling gate is opened and parts flow into standard NesTier boxes

arrangement (release of valuable square feet of plant space) and housekeeping standards (cleanliness, orderliness) can be a step toward automation.

Importance of Systematic Handling

A major area for improving housekeeping functions revolves around small parts handling. A study of the various products and industries yields a list of thousands of items such as bolts, nuts, screws, washers, small machined parts, springs, clips, fasteners, stampings, small castings, fittings, rubber and plastic parts and a myriad of other items generally classified as small parts. Obviously small parts handling can represent an important cost element in some of the products being manufactured or assembled for outlet in our increasingly competitive markets.

In those cases where the problem of handling these parts receives little or no attention, the end results are evidenced by:

1. Needlessly high production costs created by parts loss and damage.
2. Excessively high investment in small parts inventory caused by obsolescence, duplication and unsatisfactory production scheduling practice.
3. Poor housekeeping conditions generally accompanied by substandard employee morale, poor quality control interest, high accident rates, and below average customer satisfaction.
4. Misuse of work and storage space which results in a spiraling pattern of disorganization, untidiness and wasted investment in material and man-hours.

The Dearborn Engine Div. of the Ford Motor Co. regularly receives thousands of tons of small parts and hardware. The control and handling of these parts furnishes an example of a modern, rapid and inexpensive solution to the problem of small parts handling.

Most of the items received at the Dearborn plant are packaged by the manufacturers in cartons or kegs which weigh from 250 to 300 lb each. Generally these containers were sent directly to the assembly line. This, in some instances, resulted in clutter and dunnage at the least desirable point. Parts inventory control was difficult because the total small parts records were spread over a wide area. In addition, the necessity of "man-handling" heavy packages required the constant availability of a husky crew of materials handling men. Mobile transport equipment was used to excess because it was impossible to "aim" parts in precise quantities to production areas where they were required. Storage space was at a premium because of the natural tendency for small parts inventories to grow on a horizontal level as the production rates increased.

Working with the Chas. Wm. Doepke Mfg. Co., engineers at the Ford Plant have developed a system for breaking down all large containers to smaller unit loads at one central point before movement of the parts to the production area.

Fig. 2—Standard size boxes containing various parts needed in an area can be neatly stored, resulting in a real saving in space at most critical point—on the production line

As pallet loads of cartons and kegs of small parts arrive at this point directly from the receiving dock, parts are transferred to standard NesTier boxes. These boxes are designed to tier when in use and nest when empty to simplify storage and movement. A standard NesTier rollover carton dumper is utilized in combination with a simple light capacity hoist to fill individual boxes.

▸ Advantages of Orderliness

Transfer of parts to standard containers means that all movement of various sized cartons and kegs is limited to one area; small parts move into position at the assembly lines in neat, orderly tiered containers which eventually provide a hopper-like means for final part distribution. The initial investment to set up this new method was quickly recovered by the reduction in man-hours required in materials handling, the improved service to the assembly line, and reduction of area shortages, parts loss and damage. Creation (actually recovery) of valuable floor space at the assembly line (where it is most vital) was effected by elimination of dunnage, empty kegs and cartons at this point. Reduced fire hazards and better plant appearance are important secondary gains.

It is of particular interest to note that the savings at Ford in handling a large variety of parts have been gained through the use of standard rather than special materials handling equipment. Considering the total cost of creating special equipment which in the final analysis is only a revision of available standard forms, it is probable that the burden of proof should always lie with the decision to create special equipment for materials handling.

Since there is a direct connection between labor atmosphere, plant morale and plant appearance, management will be well rewarded by continual interest in cost control, space utilization, tidiness and cleanliness achieved through small parts control.

Fig. 3—Breakdown of large bulk packages into smaller loads results in smaller inventories and more effective distribution of identical parts within the plant. Effective organization of small parts distribution can favorably influence overall housekeeping conditions

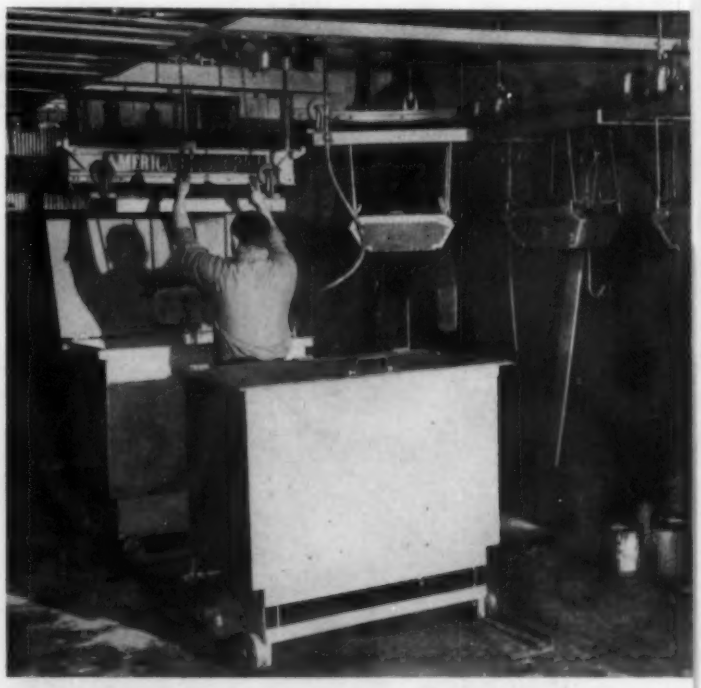


Fig. 4—When small parts require special treatment, such as degreasing or cleaning, basket form of container can be used without having to transfer parts to and from a special container

BASIC PROCESS CONTROL

Part 4

By C. W. WORLEY
Application Engineer
Brown Instrument Div.
Minneapolis-Honeywell Regulator Co.
Philadelphia, Pa.

AUTOMATIC CONTROLLERS . . .

USES AND OPERATING CHARACTERISTICS

Understanding of controller operation is necessary to visualize control utility. Few controllers are purely electrical, mechanical, pneumatic or hydraulic devices. A high degree of similarity exists between all types and their theoretical characteristics are basically the same. From this fundamental vantage point and with a classification of the control modes now in common use, optimum control action may be selected commensurate with the degree of quality required

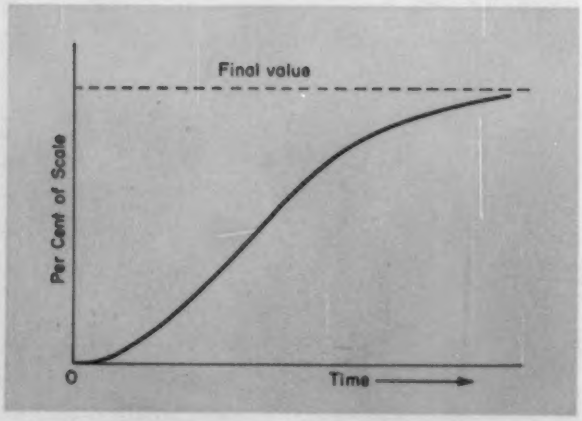


Fig. 1—Transient response of a process for a step change in input. This example has the general characteristics of an overdamped second-order system since the initial response is small, the largest rate of change occurring sometime later. Thereafter the slope progressively becomes smaller

IN ANALYZING a specific control problem, a choice must be made among the various modes of control to select the optimum method. Generally speaking, the more difficult the control problem, the more complicated the control action must be for effective control. This is not meant to infer that a complicated controller is necessary to obtain good control, for the simplest mode is sometimes capable of providing a high quality of control. All criteria for judging stability of control are derived from the purpose for which the control system is to be used and the requirements it must satisfy. The quality of control is, therefore, always relative in the sense that it must necessarily depend upon factors peculiar to each application. For this reason, no general rules of application for the different types of control action can be made.

Automatic controllers regulate the performance of a given process by controlling the application or flow of power to the system. The power source

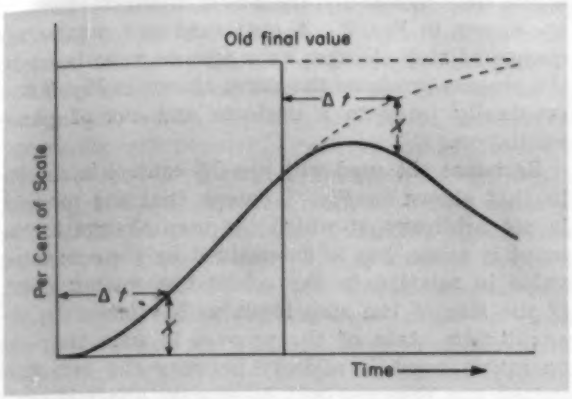


Fig. 2—Transient response of a process to a sudden reversal of input. This curve is identical with that of *Fig.* 1 up to the point of reversal

which is controlled is usually external to the system and, in general, is at a higher energy level than the signals generated in the control system. This energy level is a measure of the ability of the system to perform external work and in effect determines the sensitivity of the control system.

Action of the automatic controller is dynamic because of the continuous, changing character of the energy transfer within the controlled system. Automatic control rarely achieves a steady-state of balance, but operates rather to maintain controlled conditions within desired limits. It is the purpose of the controller to hold to a minimum any deviation from the desired balance of the process.

Since the action of the controller is dynamic, its performance can be expressed as a differential equation. Also because of this dynamic action, characteristics of automatic controllers may be expressed in transfer function or frequency response form. By means of feedback control techniques, controller characteristics may be combined with the characteristics of other components in the control system to indicate performance of the entire system.

The automatic controller functions according to changes in the controlled variable indicated by the measuring element, and produces the counteraction necessary to maintain the desired state in the process. The method by which the controller produces the counteraction is called the mode of control. There are four important modes used in process control which may be regarded as basic. They are: (1) two-position, (2) proportional, (3) integral, and (4) derivative. Actual process controllers are available with a single basic mode of control action or as a combination of more than one mode.

The controller may then be defined as that combination of components which utilizes the difference (the error e) between the actual state of the measured variable and the desired state to determine the flow of power to the process. The controller may be a simple device consisting of one or two basic components, or it may be a complex device including electronic, electrical, mechanical, pneumatic, or hydraulic devices in various combinations. Nature of the error signal, the power source, and the output signal to the process all influence controller complexity. Few controllers are purely electrical, mechanical, pneumatic, or hydraulic devices, and therefore no attempt will be made to classify them physically. However, there is a high degree of similarity between controllers used in different control fields, since their theoretical characteristics are basically the same. For this reason only the theoretical performance of automatic controllers will be discussed here.

As is the case with almost all physical devices, the performance of automatic controllers actually encountered is represented only approximately by the basic theoretical mode of control. In general, these approximations are due to limitations involved in the design of the controller and arise from two distinct causes: (1) tolerances of their construction, and (2) difficulty in predicting actual performance of the means employed. In both cases the practical difficulties are often considerably affected by the relatively small movement or force produced by the measuring unit and the consequent need for amplification in order to operate the final control element.

▶ Two-position Control

Simplest form of control is one in which only two settings of the regulating unit are available, one leading to a higher value of controlled variable and one to a lower value of controlled variable. This type of control, sometimes called *On-Off*, is one in which the final control element is quickly moved to the highest or the lowest position when the controlled variable reaches a predetermined magnitude. The simple home thermostat is an example of this type of control. When the tem-

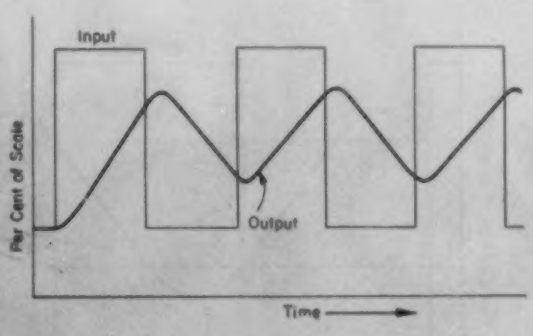


Fig. 3—Transient response of a process to a square wave input. This input is merely the cyclic application of sudden reversals of input and hence can also be determined by use of the principle of superposition

perature is above the desired value the heater is *Off*, and when the temperature is low the heater is *On*. Two-position control does not act according to the rate or magnitude of deviation but reacts only to fixed magnitudes of the controlled variable.

In order to obtain the response of the controlled variable for this type of control action, it is necessary to consider the effect of sudden and sustained changes of the final control element such as a step change made to the process. In Part 2 of this series the response of a physical system to step changes in input has been shown to depend upon the inherent energy transfer characteristics of the system. *Fig.* 1 shows an example of the response of a process to a step change in input, the previous condition having been one of equilibrium.

It is often necessary to consider the effect of discontinuing the input change instead of allowing the change to have its full effect. This interruption can be regarded as an equivalent step change in the opposite direction and occurs at a time when the system is not in equilibrium. The effect of the original change is retained and continues to have effect. Since the second step change is of the same magnitude but of opposite sign, the net change is zero and the variable eventually tends toward the original equilibrium state before it was disturbed.

In order to give a simple explanation of the response for this type of control, a linear system will be assumed. Although this is not the actual case, such an assumption will yield a reasonable approximation. The assumption of a linear system allows use of the principle of superposition which states that if the effect is proportional to the cause, and if several causes act simultaneously, the total effect is the sum of the individual effects. This principle can be used to obtain the total response by subtracting from the curve of *Fig.* 1 an identical curve displaced in time by the interval during which the original disturbance is in effect. Results are shown in *Fig.* 2. A continued and regular sequence of step changes as a square wave input to the process produces the curve shown in *Fig.* 3 and eventually leads to a uniform and out of phase oscillation.

Response obtained with *On-Off* control is similar to that shown in *Fig.* 3 except that the moment is not arbitrary at which the step change to the input is made, but is determined by the measured value in relation to the selected operating point. If the size of the step input with relation to the equilibrium state of the process is such that the operating point is midway between the two final values, the response will be exactly one-half cycle out of phase with the control action.

This usually high frequency of oscillation may give rise to operating difficulties with contacts, valves, and other operating mechanisms due to frequent or uncertain operation, particularly when the effective system time constants are small. For this reason, two-position control sometimes has a differential gap in which the final control element remains in its last position until the controlled variable has moved slightly beyond the control point. The resulting performance depends on the amount of dead zone or differential gap. For the example of *On-Off* control with differential gap shown in *Fig.* 4, the frequency of oscillation has been reduced, and consequently the number of times that the regulating unit is operated has been reduced. However, the amplitude of the cycle has been increased.

With a larger gap the frequency will become still less and the amplitude still greater. Accordingly, it becomes necessary to select a differential gap which effects a satisfactory compromise between frequency and amplitude of cycling consistent with the requirements of the particular control application. It follows then that the actual shape of an *On-Off* control performance curve, the

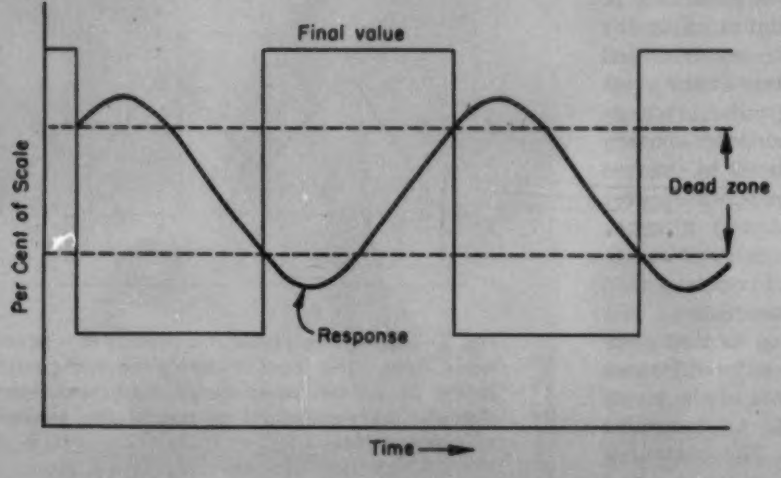


Fig. 4—Response of *On-Off* control with dead zone. If the size of the step input with relation to the equilibrium state of the process is such that the operating point is midway between the two final values, the response will be exactly one-half cycle out of phase with the control action

frequency, amplitude and mean value, are greatly affected by the actual nature of the process characteristics and by the size of the input changes.

Because of its simplicity, two-position control by either pneumatic, electric, or direct mechanical means is very popular. Perhaps the greatest use for this type of control is found in the air conditioning and refrigeration industry. This mode of control is also used in many industrial applications as the only mode of control or as a safety device in the control loop. When failure of some component in the main control system could cause an emergency condition such as excessive level in a tank, pressure in a vessel, or temperature in a process, a safety device such as an inexpensive two-position controller will prevent damage and loss of property.

It has been shown that the response of two-position control is essentially cyclic, although under almost ideal conditions the magnitude of variation in the controlled variable may be made extremely small. It is obvious, however, that certain limitations exist in the application of two-position control. Assuming that the measuring and controller lags are not negligible, as they seldom are in temperature control, the process must possess certain other desirable characteristics.

Most important requirement for obtaining a small amplitude of cycling of the controlled variable is that any delay in response of the process variable for changes in the final control element must be as small as possible. This means that two-position control cannot successfully be used on processes which have a high-order response, systems with dead time (any definite delay period between two related actions) or systems with large measuring lags, since these system characteristics will result in a highly oscillatory response. Two-position control can be used successfully on fast processes having small time constants where the dead time is practically zero. Larger process time constants or slower processes allow a slight amount of dead time without exceeding close limits of cycling of the controlled variable.

Proportional Control

In order to overcome the inevitable sustained oscillations which are characteristic of the discontinuous type *On-Off* control, a type in which the control action is continuously related to the controlled variable is used. The simplest continuous relationship is one involving direct proportionality, and results in a control mode known as proportional control. Sometimes called throttling, or modulating control, proportional control results in a controller action proportional to its input and thus maintains a continuous balance of the input and output energies.

Using the techniques of the feedback control engineer, we can express the proportional mode of control, by definition, as

$$\frac{X_o}{e}(s) = K_c \qquad (1)$$

where X_o is controller output, K_c is controller gain, and e is the control error signal or the difference between the desired value and the actual value into the controller. Equation 1 is the transfer function of a theoretical proportional controller.

For purposes of flexibility of application, an adjustment of the gain or the proportionality factor between the controller output and input is usually provided. This means of adjustment is commonly called the controller proportional band or throttling range, and is defined as the percentage of full-scale change of the controlled variable required to position the final control element from one limit to the other in its operating range.

From this definition the proportional band is seen to be the reciprocal of the actual controller gain,

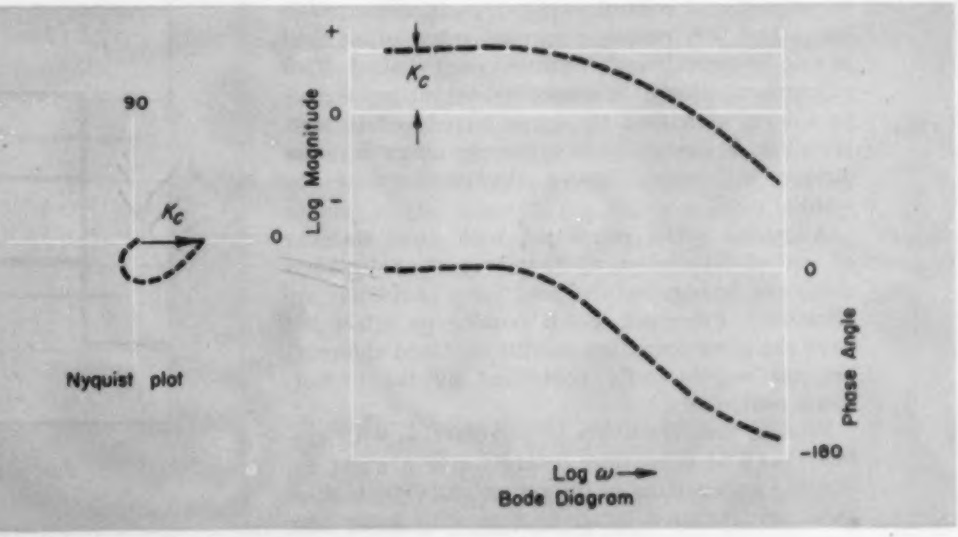


Fig. 5 — Frequency response curves of proportional control. This mode of control has a theoretical frequency response which is independent of frequency and which can be represented as a point on the zero axis in the polar plot and as a straight line on the log plot. Frequency response of an actual controller is shown as a dotted curve

since gain is defined as the ratio of the output to the input (final control element position for a change in controlled variable). Therefore,

$$K_c = \frac{100}{\text{Proportional band in per cent}} \quad \ldots\ldots\ldots\ldots (2)$$

Since the control action of a proportional controller is continuous rather than discontinuous, the mathematical equation expressing its theoretical performance is a linear differential equation, and linear feedback control techniques can be used to express its operating characteristics. As such, its performance can be expressed in frequency response terms. *Fig.* 5 shows the Nyquist plot and Bode diagram of the proportional mode of control.

Since the theoretical response of a proportional controller is independent of frequency, it has no phase shift. It should be realized that a pure proportional response would be difficult to design into a practical controller, since any physical system will have energy transfer characteristics which effect the output at relatively high frequencies. The frequency response of an actual controller is shown as a dotted curve in *Fig.* 5. Practically speaking, this controller can be considered to have a theoretical response over a useable frequency band.

Transient response of the theoretical proportional controller is easily visualized since the output is some proportion of the input. Curves of *Fig.* 6 show response of the proportional mode for a step change in input to the controller (the error). Note that the maximum output varies as the proportional band is changed. From the definition of proportional control given in Equation 1 it follows that if a controller output X_o is required to operate the system, an error e must exist. This error is known as offset; it is the main disadvantage of proportional control, since the controller can never cause the actual value of the controlled variable to be equal to the desired value.

Curves of *Fig.* 6 show that by increasing the gain (reducing the proportional band) the offset can be reduced, but, since this controller is part of a closed loop, this will cause the control system to approach an oscillatory state, and the advantage of proportional control over two-position control is lost. For this reason a manual reset adjustment is usually provided with proportional control. This adjustment allows the controller output to be reset to a level such that the error is reduced to zero. However, a change in the process operating conditions will necessitate a readjustment of the manual reset.

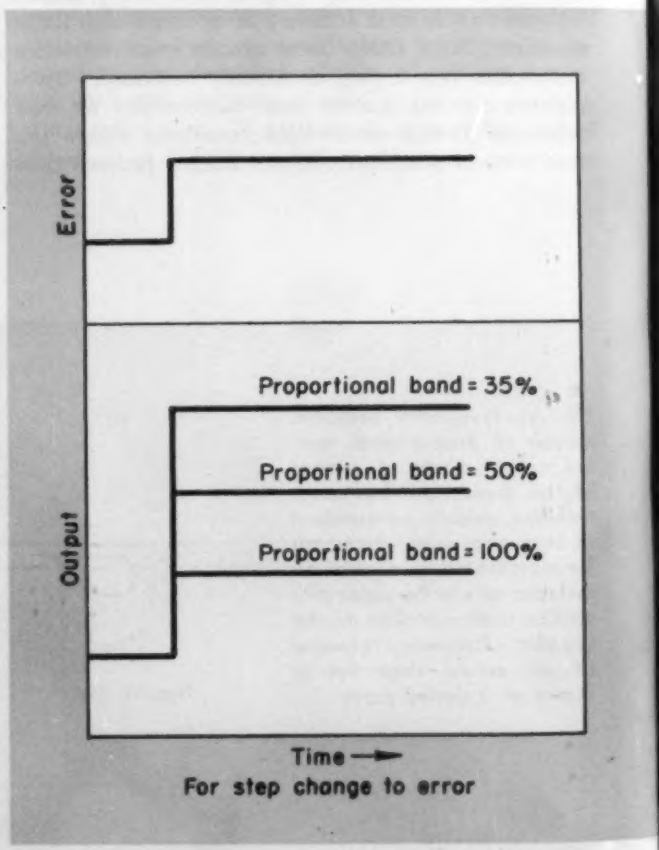
Allowable offset consistent with good stability of control determines whether proportional control alone can be successfully used for a particular application. Processes which require no offset but have changing operating conditions (load changes) are not satisfactorily controlled by the proportional controller.

Process time constants in combination with system lags and dead time determine to a great extent the gain setting of the controller. The highest gains are required for a process with large time constants, small measuring lags, and small dead times. The offset caused by load changes in this process are small. When the process time constants are smaller, the gain required is smaller and more offset is obtained. In general, processes having large measuring lags, large dead times, and higher-order response characteristics require smaller gains and, hence, more offset results.

Integral Control

Proportional control results in an offset or droop of the controlled variable whenever load changes occur in a process. To overcome this difficulty another type of control, known as integral control or floating control is available. Integral control is defined as control action in which there is a predetermined relation between the value of the controlled variable and the rate of motion of the final control element.

In integral control, the final control element is gradually moved toward either the open or closed position, depending upon whether the controlled variable is above or below predetermined magnitudes. With this type of control action, so long as there is a deviation, the correction is continuously and progressively changed in such manner as to reduce the deviation. With this relationship between the controller input and output, it is impossible for



the controlled variable to come to rest at a value other than the desired one, because at any such value the correction continues to be made. Consequently, offset is not possible.

Unlike proportional control, where there is only one basic type to be considered, there are several types of integral control available depending upon the speed of correction of the final control element.

Different types of integral control are known as single speed floating, multispeed floating, and proportional speed floating. The integral mode of control may be used alone to control a process or it may be used in combination with proportional control. The most commonly used type of integral control in industrial automatic controllers is the proportional speed type, which is known as automatic reset or reset.

Single-speed floating control behaves much like the two-position controller—pure integral control tends to give an oscillatory response, so a neutral zone or gap is provided, within which the final control element remains at rest. When the measurement has exceeded either the upper or lower limits of the neutral zone, the final control element starts moving at a constant speed.

Since the speed of correction of the deviation is constant regardless of the size of the error, there is no direct relationship between the final control element and the amount the controlled variable has deviated from the set-point. Therefore, there is not a linear relationship between deviation of the controlled variable and final control action as there was with proportional control. For this reason it is impossible to express single-speed floating control action by a simple differential equation.

However, it is not difficult to visualize the response of this control mode from its definition. When an error is detected, the control element acts in a direction to correct the deviation at a constant speed until the error is corrected or until the control element reaches its limit. Responses of this mode of control for a step-change and a sinusoidal change in the input of the controller are shown in *Fig.* 7. Opposite direction between the controller input and control action is necessary in order to eliminate the deviation.

Greatest advantage of single-speed floating control is that gradual changes in process load can be counteracted by a gradual shifting of the final control element. If all lags are small, corrective action can be completed with very little deviation from the neutral zone. However, if load changes occur suddenly, deviation cannot be avoided since the final control element has only a single speed of motion regardless of the magnitude of deviation, and this speed cannot be determined optimally for rapidly changing loads.

In addition, single-speed floating control gives satisfactory control for processes having small time constants where two-position control cannot generally be applied. As a general rule, successful use of this type of control is usually restricted to processes which possess a large degree of self-regulation. As with *On-Off* control, the dead time in the system should be small.

Multispeed floating mode is a type of control action in which the control element is given any one of several speeds depending upon whether the controlled variable is close to or far from the control point. Thus this type of controller recognizes elapsed time of deviation and, to a limited extent, the magnitude of deviation. In many applications where load changes occur quickly, multispeed floating control can be used to limit the deviation. The faster floating speeds at the wider limits of deviation produce a faster correction and tend to reduce the amplitude of cycling.

Proportional speed floating control action is the type frequently combined with proportional control to give reset response. In this type of control the final control element is moved at a rate dependent upon the magnitude of deviation of the controlled variable from the set-point. For example, if the controlled variable rises a certain amount above the control point, the control element begins to close at a constant rate. If the

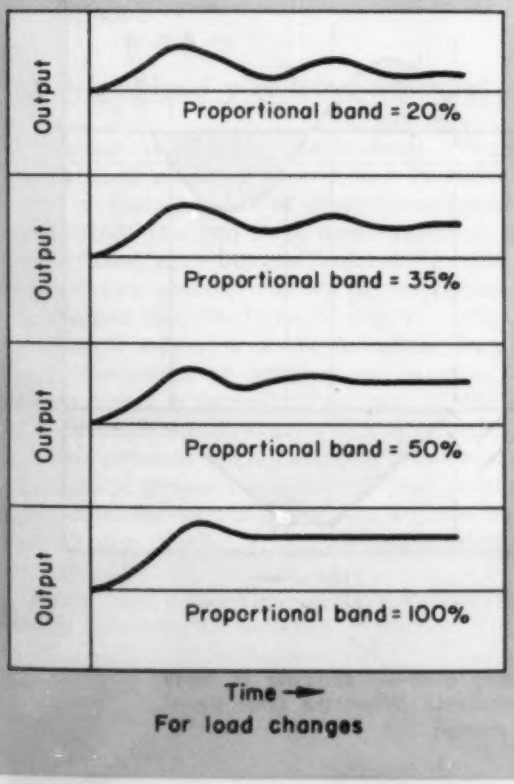


Fig. 6—Transient response of proportional control for a step change in input to the controller and for load changes. In this mode of control the controller can never cause the actual value of the controlled variable to be equal to the desired value

deviation becomes twice as great, the control element moves twice as fast. When the variable is at the set-point, the control element remains stationary. Thus a proportional-speed floating controller recognizes not only elapsed time of deviation but also magnitude of deviation.

Expressing the definition of integral control mathematically, we have

$$\frac{dX_o}{dt} = -\lambda_R e \quad \ldots\ldots (3)$$

where dX_o/dt is the rate of change of the controller output, λ_R is the floating rate, and e is the error signal into the controller. This action can be expressed directly in terms of control element movement or controller output by integrating Equation 3.

$$\int_{X_{o1}}^{X_{o2}} dX_o = -\lambda_R \int_0^t e\,dt \quad \ldots\ldots (4)$$

or

$$X_{o1} - X_{o2} = -\lambda_R \int_0^t e\,dt + K \quad \ldots\ldots (5)$$

where K is the constant of integration depending upon the initial controller output. The floating rate λ_R is a function of the gain of the controller and the floating rate of the integral action. In a later discussion of the proportional plus reset combination this coefficient will be defined in terms of the time constant associated with the integration of the error.

Equation 5 can be used to show the effect of changes in the error on the controller ouput for this type of control. It is obvious that the response to step changes of the error would be exactly the same as that shown in *Fig.* 7 since the magnitude of the deviation remains constant until the time when the step change is reversed. Consequently, in order to show the difference in control effort, the controller is forced with a sinusoidal input, *Fig.* 8.

Equation 5 can be expressed in LaPlace form as

$$X_o(s) = -\lambda_R \frac{e}{s} \quad \ldots\ldots (6)$$

and the transfer function for the proportional-speed floating controller becomes

$$\frac{X_o}{e}(s) = -\frac{\lambda_R}{s} \quad \ldots\ldots (7)$$

The polar plot and log plot of this transfer function as a function of frequency are shown in *Fig.* 9. The phase lag is independent of frequency and is always equal to -90 degrees phase shift. Gain varies inversely as the frequency; the higher the frequency the smaller the gain. The amount of gain obtained at a particular frequency depends upon the relative size of the floating rate coefficient λ_R.

As is the case with the proportional controller, the control action can be adjusted by selecting the

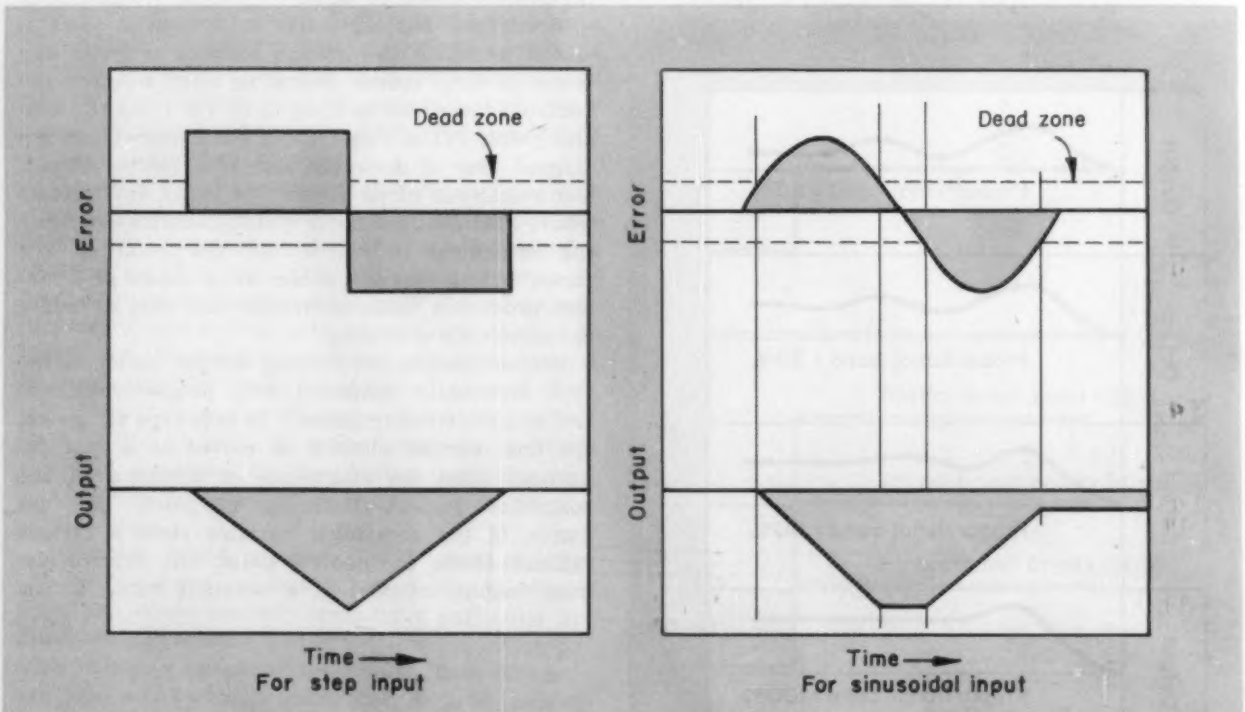


Fig. 7—Transient response of single-speed floating control. Behavior of these controllers is similar to that of two-position controllers. When the error signal is within the dead zone, the output does not change

proper floating rate, and thus the desired stability of control can be obtained. A fast floating rate results in excessive cycling, while a slow floating rate produces an overdamped or sluggish control response. However, this type of controller does not require a neutral zone in order to give a stable control system due to the fact that the speed of operation of the control element is dependent upon the deviation of the variable. When the deviation is zero the control element is stationary.

Proportional-speed floating control does not immediately correct for sudden load changes in the process, although the controlled variable is eventually returned to the control point. However, its performance for process load changes is more acceptable than proportional control alone. In applying proportional-speed floating controllers to process control it is important that an instantaneous reaction of process and controller be obtained. This means that measuring lags must be small, and dead time must be negligible. Also, multicapacity processes having a sluggish response together with this type of controller should be avoided.

If the process time constant is small, proportional-speed floating control is more effective. If the process time constant is large the period of cycling will become large and the floating rate must be reduced. Again dead time must be small, although a fast process will tend to overcome some of the difficulties normally encountered with dead time. Application of proportional-speed floating controllers is generally such that a relatively high-speed final control element is required in order not to limit the action of the controller. Lag of the controller itself should be small in order that the control element consistently receives the rate of motion signals called for by the magnitude of the deviation.

▶ Proportional plus Integral Control

In order to overcome the inherent offset of the proportional mode of control and to increase the speed of control action of proportional-speed floating control, the two have been combined to give proportional plus integral control. As the name implies, this control consists of simultaneous application of the two types of control action to accomplish a reduction of the deviation. In the previous discussion of proportional control it was observed that a manual adjustment of the output of a proportional controller was necessary to provide for different plant operating conditions. Combination of proportional control and proportional speed floating control causes the adjustment to be made automatically, giving automatic reset of the controller output.

From the definitions of the various control modes previously discussed, it follows that this control action can be expressed as

$$X_o(t) = K_c + \lambda_R \int_0^t e\,dt \qquad (8)$$

where λ_R is the reset coefficient.

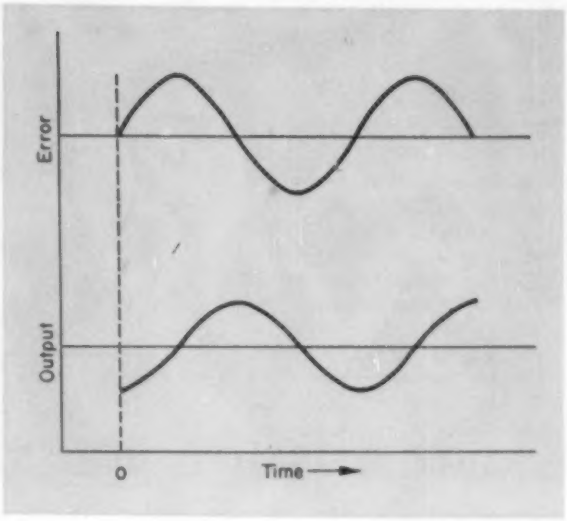


Fig. 8—Transient response of proportional-speed floating control for sinusoidal input. Corrective action of the proportional-speed controller is proportional to the deviation. Controller output does not vary over as wide limits as in single speed floating control, correction is faster and amplitude of cycling of the controlled variable is reduced

Proportionality factor associated with the integral of the error can be shown to be a function of the controller gain and the floating rate of the integral action. Differentiating Equation 8 gives

$$\frac{dX_o}{dt} = \lambda_R e \qquad (9)$$

Thus, with a constant error the controller output will increase or decrease (depending on whether the actual value of the controlled variable is smaller or greater than the desired value) at a constant rate of $\lambda_R e$. After unit time of one minute, the output change due to integral action will be

$$1\,\frac{dX_o}{dt} = 1\,\lambda_R e \qquad (10)$$

Initially, upon receiving an input, there will be a controller output of $K_c e$ due to the proportional action alone. The ratio of the control action due to the integral mode expressed by Equation 10 to this proportional action is $1\lambda_R e/K_c e$ and is the number of times the integral action has repeated the proportional action. Assume this to be $1/\tau_c$ or the number of repeats per minute due to integral action. Then

$$\frac{1\,\lambda_R e}{K_c e} = \frac{\lambda_R}{K_c} = \frac{1}{\tau_c} \qquad (11)$$

or

$$\lambda_R = K_c \frac{1}{\tau_c} \qquad (12)$$

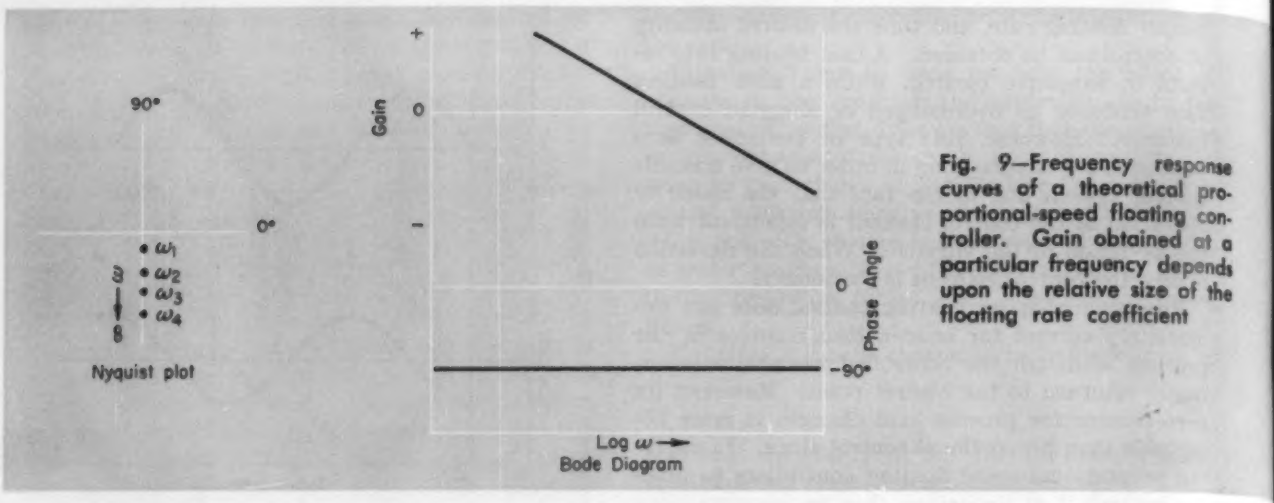


Fig. 9—Frequency response curves of a theoretical proportional-speed floating controller. Gain obtained at a particular frequency depends upon the relative size of the floating rate coefficient

Equation 8 can now be rewritten as

$$X_o(t) = K_c e + K_c \frac{1}{\tau_c} \int_0^t e\,dt \quad \ldots\ldots\ldots\ldots (13)$$

This can be expressed in LaPlace form as

$$\frac{X_o}{e}(s) = K_c \left(1 + \frac{1}{\tau_c s}\right) \quad \ldots\ldots\ldots\ldots (14)$$

Therefore, the transfer function of the theoretical proportional plus integral controller is

$$\frac{X_o}{e}(s) = K_c \frac{\tau_c s + 1}{\tau_c s} \quad \ldots\ldots\ldots\ldots (15)$$

Nyquist plot of this transfer function is shown in *Fig.* 10. At low frequencies, as ω approaches zero the gain increases indefinitely and the phase angle increases toward −90 degrees. This characteristic of having a high gain at low frequencies shows the integrating action of the controller. If this type of controller receives a low-frequency error or steady-state (zero frequency) error it would generate a large output in an effort to reduce the deviation. In fact, the controller output would soon reach its maximum or limit as often happens in starting a batch-type process. At higher frequencies the gain approaches unity and the phase lag approaches zero. In other words, at low frequencies the proportional plus integral controller acts as a pure integral controller and at high frequencies it acts as a pure proportional controller.

Bode diagram of the two-mode controller is also shown in *Fig.* 10. This curve more clearly shows the fact that at low frequencies the controller gain is high. The effect of changing the reset rate on the frequency response is shown by the dotted curves. Changing the reset rate causes the corner frequency $1/\tau_c$ to vary, producing a different gain and phase shift for a particular frequency. Decreasing the integral time constant τ_c (increasing the reset rate) will cause the gain and phase curves to move to higher frequencies. As the reset rate is decreased (integral time constant increased) the frequency response is moved to a lower band of frequencies.

This implies that the amount of phase lag at a particular frequency can be varied by adjusting the reset rate. This is the technique used in arriving at suitable controller settings by the frequency response method. An open-loop phase lag which gives the desired system stability is selected and the reset rate is adjusted to obtain this selected open-loop phase lag and the desired damping characteristics of the system. A gain of unity at the frequency where the selected open-loop phase lag occurs is obtained by adjusting the controller gain which merely moves the frequency response gain curve up or down without effecting the phase shift.

The proportional plus integral controller may usually be applied to any process having characteristics suitable for the use of either mode separately. In addition, there is no requirement for self-regulation in the process as with proportional speed floating control, since the proportional response provides the necessary stability. Processes with multicapacity response characteristics may be successfully controlled as long as the system sensitivity is high. Dead time, as usual, is to be avoided because of the attendant slow system response for stable operation.

Size of the effective time constants for a process usually dictates the size of the reset rate. Larger process time constants require a small reset rate while small time constants permit large reset rates, providing that the dead time is small. Presence of dead time requires that the reset rate be considerably decreased in order to avoid excessive cycling of the controlled variable. As such, temperature control systems require small reset rates while flow and pressure control systems require large reset rates.

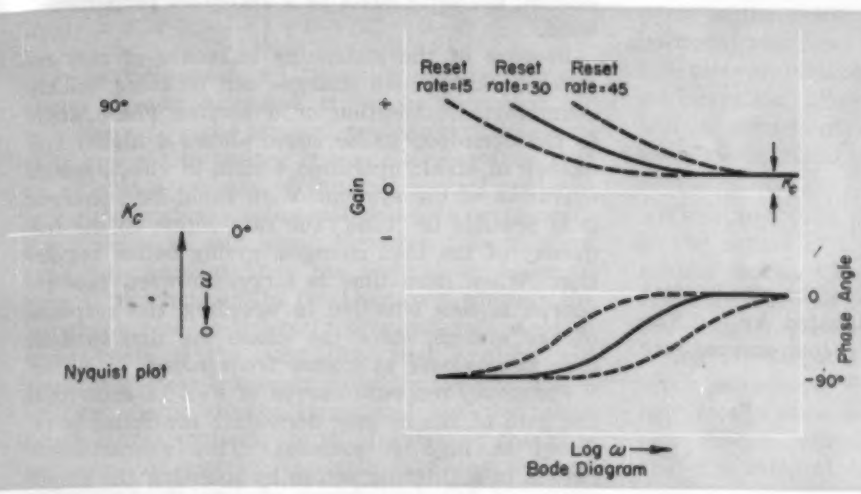


Fig. 10—Frequency response of proportional plus reset controller. For large frequencies the gain approaches unity and phase angle approaches zero. As the frequency approaches zero, the phase angle increases toward -90 degrees and the gain increase to the limit of the controller output. The three reset rates plotted on the Bode diagram show the effect of changing reset rates

▶ Proportional plus Derivative Control

Need for derivative control arises from the inadequate damping produced by proportional control for processes having excessive lags. This stabilizing effect is due to the anticipatory type of action produced by a signal proportional to the rate of change of the error. Because derivative control depends solely on the rate of change of the error, it is not affected by the actual value of the deviation itself and hence it cannot be used as a single mode.

Combination of the rate mode with the proportional mode will be considered first. The theoretical expression for a proportional plus rate controller is

$$X_o\ (t) = K_c\ e + R\ \frac{de}{dt} \qquad (16)$$

where R is the rate coefficient.

To demonstrate the response of this type of control, assume that the error signal to the controller is continually increasing at a steady rate, de/dt is constant. In *Fig.* 11, the error e begins this increase at time t_o and the rate of increase $de/dt = \tan \alpha$. Plotting the output on the same time axis, the initial change in X_o is $R de/dt$ and this is followed by a gradual change $K_c e$ due to the proportional action acting on the increasing error. This proportional action will repeat the initial rate change $R de/dt$ after time τ_R minutes. At time τ_R the error will be of a magnitude e_1 and will be equal to $(de/dt)\tau_R$. Then

$$R\ \frac{de}{dt} = K_c\ e_1 \qquad (17)$$

and

$$R\ \frac{de}{dt} = K_c\ \frac{de}{dt}\ \tau_R \qquad (18)$$

Therefore,

$$R = K_c\ \tau_R \qquad (19)$$

Thus the rate coefficient R is actually the controller gain K_c multiplied by the rate time in minutes. The rate time is the time necessary for the proportional action to repeat the rate change with an error changing at a constant rate. Equation 16 can be written as

$$X_o\ (t) = K_c\ e + K_c\ \tau_R\ \frac{de}{dt} \qquad (20)$$

which in LaPlace form is

$$\frac{X_o}{e}\ (s) = K_c\ (1 + \tau_R\ s) \qquad (21)$$

Polar and Bode plots of Equation 21 are shown in *Fig.* 12. The characteristic of having large gains at high frequencies is the major disadvantage of pure rate control. Most industrial processes encounter spurious noise signals occurring at a higher frequency spectrum than the system components. As a result of the high gain due to the rate action, the control system will receive unwanted disturbances causing unstable control. To overcome this a practical rate controller employs what is called compensated rate, which has a finite gain at high frequencies. The amount of compensation depends upon the particular design of the controller. The characteristics of compensated rate action may be illustrated by frequency response curves, *Fig.* 13.

Transfer function of the compensated rate controller is a combination of the lead-lag circuits and can be expressed as

$$\frac{X_o}{e}\ (s) = K_c\ \frac{1 + \tau_1 s}{1 + \tau_2 s} \qquad (22)$$

Maximum gain obtained at high frequencies can be found by allowing $s = j\omega \rightarrow \infty$. Thus

$$\frac{X_o}{e}\ (s)\ \Big|_{j\omega \rightarrow \infty} = K_c\ \frac{\tau_1}{\tau_2} \qquad (23)$$

Steady-state gain is obtained by investigating the limit of Equation 22 when $j\omega \rightarrow 0$. This is

$$\frac{X_o}{e}(s)\Big|_{j\omega\to 0} = K_c \qquad (24)$$

Ratio of the maximum gain to the steady-state gain, τ_1/τ_2, is sometimes designated by α. The theoretical transfer function of a compensated rate controller now can be expressed as

$$\frac{X_o}{e}(s) = K_c \frac{1+\tau_R s}{1+\frac{\tau_R s}{\alpha}} \qquad (25)$$

The ratio of leading and lag time constants is usually fixed by the design of the controller and varies from $\alpha = 6$ to $\alpha = 15$ for commercially available industrial controllers. The proportional gain term K_c is usually fixed at unity for rate units used in combination with proportional plus reset controllers.

Another type of compensated control action is obtained if the corner frequency of the lag term is designed to occur before the corner frequency of the lead term. Its frequency response characteristics are also shown in *Fig.* 13. This type of control action is called inverse derivative since its frequency-response curve is the inverse of the compensated rate curve. The constant is now equal to a value less than unity, with the exact value again depending upon the particular design.

Phase angles associated with these two types of control modes are illustrated by the phase curves of *Fig.* 13. Maximum amount of phase lead obtained from the compensated rate controller depends upon the constant α. This is also true for the maximum amount of phase lag for the inverse derivative controller.

Rate mode of control is used principally to compensate for lags occurring in the control system. Curves of *Fig.* 13 for the compensated rate controller show that it is the only control component having a positive phase shift. This phase lead can be used to cancel some of the phase lags of the open-loop phase curves. This allows the stability point to be moved to a higher frequency giving faster response. As such, rate action may be used to counteract lags due to measuring elements, multicapacity processes, and even small dead times.

Adjustment of rate time must be made carefully since a large rate time causes excessive oscillation of the response much the same as a small proportional band or large reset rate. This is principally due to the larger gains associated with the rate action. Increasing the rate time decreases the rate corner frequency, moving the rate frequency response to a lower frequency band. This has the effect of increasing the total gain of the system, the same effect as a decreased proportion band.

Because of the stabilizing influence of rate r sponse, sudden load changes can be more quick counteracted. Addition of a leading phase ang to the open-loop phase curve allows a higher fr quency of stable operation which, in effect, speed operation of the system. With rapid load change it is possible to "tune" the rate action to the fr quency of the load changes, giving better regula tion. When dead time is large, however, rate re sponse is less effective in speeding the respons of the system, since the phase lag due to dead time is excessive at higher frequencies.

Frequency-response curves of *Fig.* 13 show that the gain of the inverse derivative controller is reduced at high frequencies. This characteristic results in a filtering action by reducing the amplitude of high-frequency signals going into the system. Such action contributes to the stability of the system since the controller no longer has to follow these spurious signals. Use of this type of control is particularly effective in controlling relatively high-speed, high-gain control systems which tend to become unstable for high-frequency input signals.

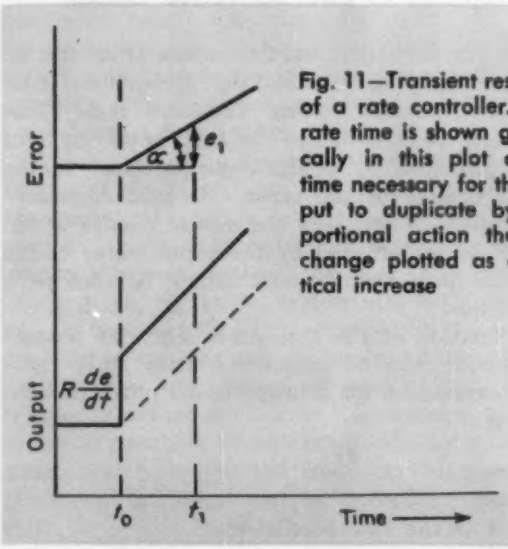


Fig. 11—Transient response of a rate controller. The rate time is shown graphically in this plot as the time necessary for the output to duplicate by proportional action the rate change plotted as a vertical increase

Plus Derivative and Integral Control

Although the addition of derivative controls improves the performance of proportional control, it does not eliminate offset. It is necessary to add integral control for this purpose, providing simultaneous application of three types of control.

By definition, the expression for a three-mode controller using pure rate action becomes

$$X_o(t) = K_c e + \frac{K_c}{\tau_c}\int e\,dt + K_c \tau_R \frac{de}{dt} \quad \ldots\ldots (26)$$

From the phase relationships of the various modes already discussed, it can be seen that the pure derivative and integral response are diametrically opposed in phase. It would appear then that an unlimited amount of integral control could be permitted, stability being satisfied by a corresponding increase in rate time. However, this does not take into account that the derivative action is directly proportional to the frequency whereas the integral action is inversely proportional. Accordingly, there is the possibility that hunting will occur at a lower frequency when the integral action will be comparatively large and the derivative action correspondingly small. In view of this it is necessary to restrict the action of the integral component. It will be found that the allowable amount of reset rates is not greatly different from the amount permissible in the absence of rate action.

Type of control expressed in Equation 26 is sometimes found in electric controllers and in certain custom-built controllers designed for special applications. However, the greatest number of commercially available three-mode controllers employs some form of compensated rate action because of the noise problem. Furthermore, rate is usually designed as a fixed gain unit which can be added to the proportional plus integral controller to give the three-mode action. This is particularly true of the pneumatic controllers used extensively in process control.

Compensated rate action can be employed in several controller schemes depending upon the particular application. The rate unit may be applied to the error signal in series with the proportional and reset action or it may be applied to the process variable signal. This later controller configuration gives better start-up performance and is particularly suitable for batch-type processes where initial overshoot of the controlled variable is critical.

These improved start-up characteristics are due to the nature of the physical arrangement of the control modes. Characteristics of integral control are such that as long as it receives a signal of one sign, it generates the integral of this error, giving an output of a magnitude such that this error is reduced. The error itself will call for a new steady-state controller output to satisfy the new process operating conditions. The only way that the integral controller can be made to generate a signal less than this new steady-state controller output is to have it receive an error of opposite sign; the controlled variable may now be larger than the desired value instead of less as originally obtained. On start-up the process variable will be small, and since the set-point is at the operating point there will be a large error. The reset action will integrate this error with respect to time and will call for a controller output which will reduce this error. In many instances the final control element will reach its limit at full controller output.

The only way that the action of the reset mode can be stopped is for the error to pass through zero, which means that the controlled variable must become larger than the desired value. Since the final control element has received large signals in an effort to reduce the large initial error, the power admitted to the process usually causes

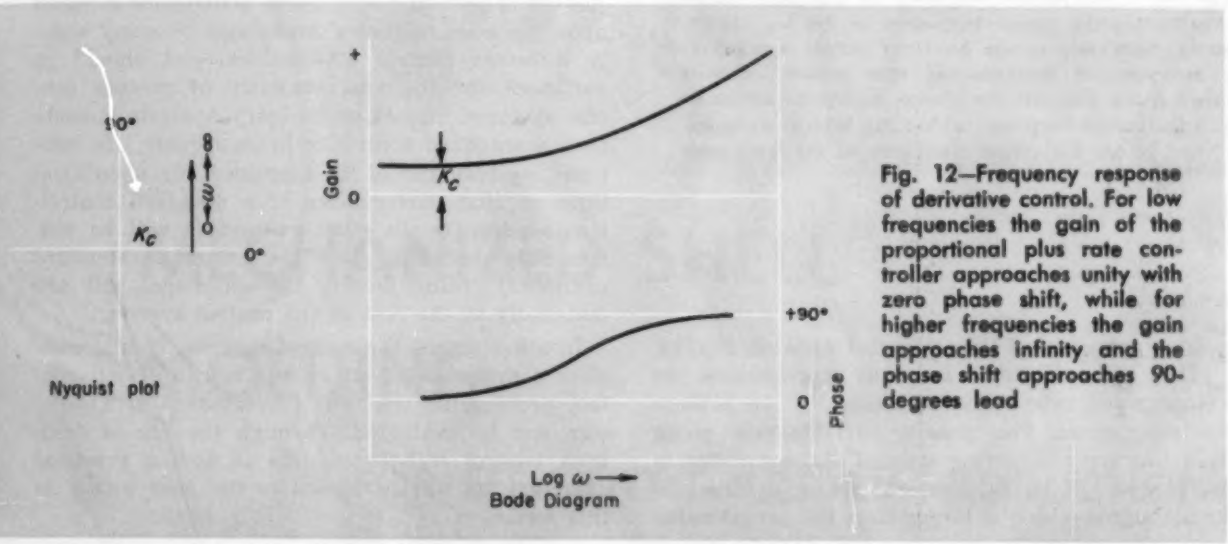


Fig. 12—Frequency response of derivative control. For low frequencies the gain of the proportional plus rate controller approaches unity with zero phase shift, while for higher frequencies the gain approaches infinity and the phase shift approaches 90-degrees lead

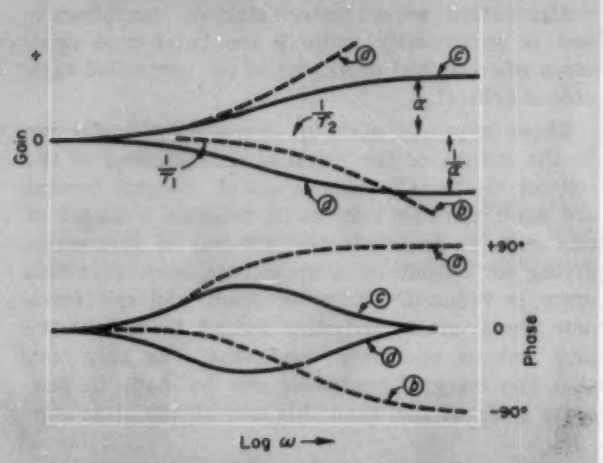


Fig. 13—Frequency response of compensated rate controller. Curves marked *a* show response of a pure rate controller, those marked *b* show response of a first order lag. The corner frequency of the lead circuit occurs before the corner frequency of the lag circuit. Adding these two curves produces curves marked *c*, the response of compensated rate action. Curves marked *d* are response for inverse derivative action in which the corner frequency of the lag term is designed to occur before the corner frequency of the lead term

a large overshoot of the controlled variable, *Fig.* 14.

This is undesirable in many applications, so compensated rate action is applied to the process variable signal. The process variable now going into the error detecting unit of the controller is influenced by the rate action, giving a false dynamic signal which is larger than the actual value of the process variable because of the high gain rate unit. As far as the proportional plus reset controller is concerned this dynamic signal is the true process variable, which would be as shown by the dotted curve of *Fig.* 14. This curve crosses the desired value some time sooner than the actual value of the controlled variable. Consequently, the reset action gives a reduced output which causes the process to receive reduced power as the actual process variable approaches the desired value. The response of the controlled variable would now be as shown in the third curve of *Fig.* 14. For proper settings of rate time and reset rate, the overshoot of the process variable sometimes can be eliminated, and a fast system response achieved.

The three-mode controller, being the ultimate in control action, may generally be applied with success to the more difficult control problem. Perhaps the only limitation to its application is the range of adjustments provided in commercially available industrial controllers. The range of adjustments provided with these controllers is based upon the manufacturers' knowledge of many widely different control applications, and should be sufficient for the vast majority of process control systems. Should preliminary analysis indicate that a standard controller is inadequate, the proposed system should be examined for simplifications so that performance of a standard controller is adequate. In most cases this will be economically desirable, since the use of nonstandard equipment, being largely custom made, will add materially to the cost of the control system.

In other words, the control engineer should complete a system analysis on the more difficult control problem so that the performance of his design can be evaluated. Through the use of feedback control techniques, this is now a practical approach, as will be shown in the next article in this series.

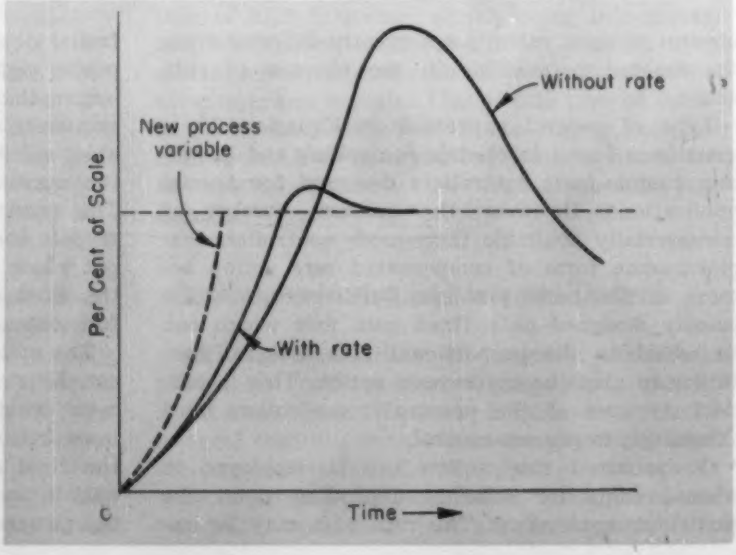


Fig. 14—Effect of rate action on process start-up response. Large overshoot may be avoided by applying compensated rate action to the process variable signal

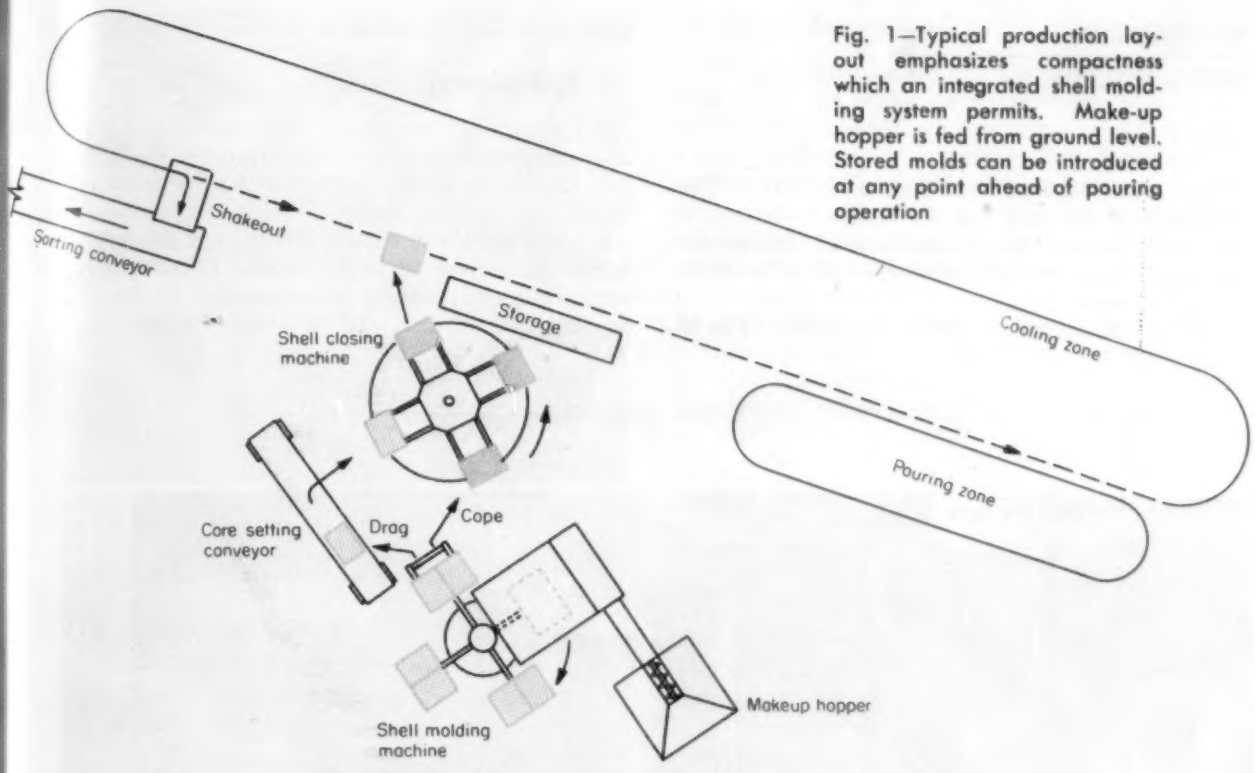


Fig. 1—Typical production layout emphasizes compactness which an integrated shell molding system permits. Make-up hopper is fed from ground level. Stored molds can be introduced at any point ahead of pouring operation

MECHANIZED SHELL MOLDING

FOR EFFICIENT FOUNDRY PRODUCTION

Technically improved form of mold production has been made automatic. The result is an example of the multiplicity of benefits which can culminate the creation of a successfully automated system

REALIZATION of low unit costs by scheduling and producing an optimum quantity in a given operation is an ever recurring problem for all manufacturers. Larger producers have the obvious advantage of dealing with quantity but other producers must strive for flexibility of operations in solving this critical problem. Interestingly enough, automation—a natural solution for larger producers—can be used in some instances to achieve the requisite flexibility for producers whose quantity is made up of a variety of items.

As an example, the technical advantages of shell molding when combined with the high production of an automated shell mold production machine and casting line offer a flexibility to foundry operations not hitherto available. In this special type of foundry operation, a mixture of sand, wetting agent and thermosetting phenolic resin is brought into contact with a heated pattern to pro-

duce a thin, tough and gas porous shell mold. The thickness of the shell can be varied by changing the temperature—time relationship of the pattern and sand at the contact point so as to set more or less of the resin.

One of the important advantages of this type of mold is its storing qualities. The light-weight shell can be handled easily and stored without warping or loss of detail accuracy. This means that mold preparation and the actual casting operation can be safely separated by a greater time interval without the use of excessive storage space or costly handling of large bulky molds. It is possible to prepare an economical quantity of shell molds and to draw upon these stored shells for the most economical casting schedule at another operation.

Operation of System

An integrated automatic shell molding system is available; it has been developed by the Link-Belt Co. in collaboration with the Walworth Co. The latter had previously developed an automated system of shell molding for ferrous and nonferrous valve bodies and fittings. In the Link-Belt system, shells are produced on a 4-station machine by one operator at the rate of 240 molds per hour.

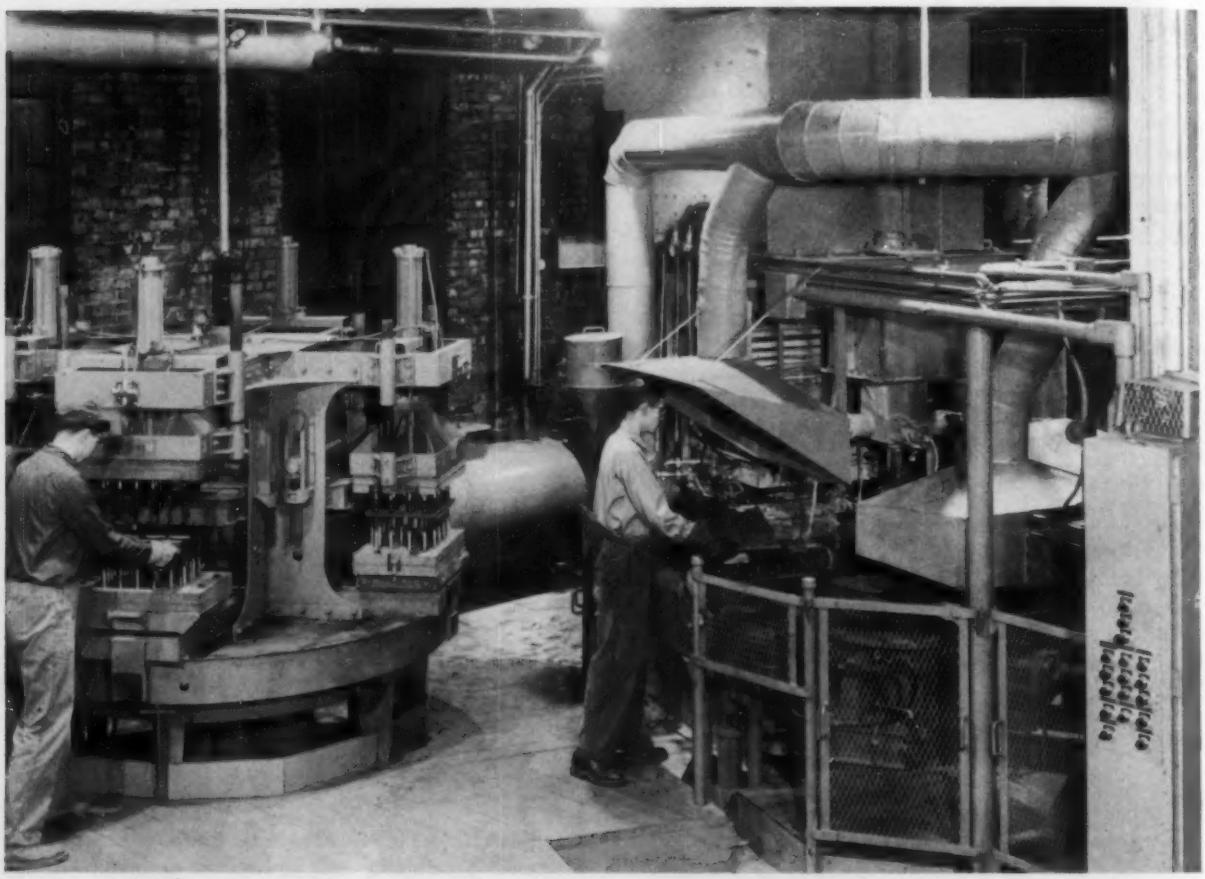
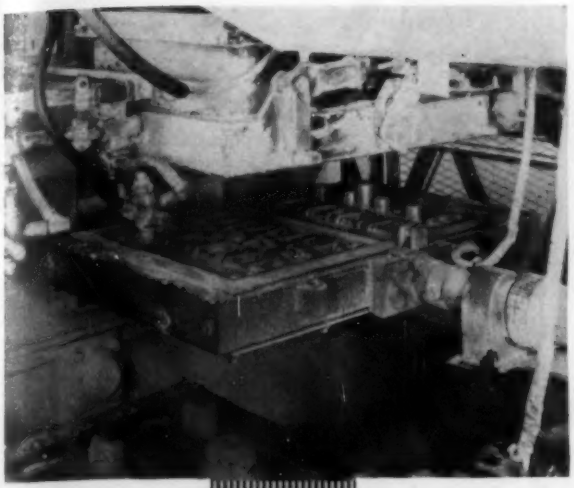
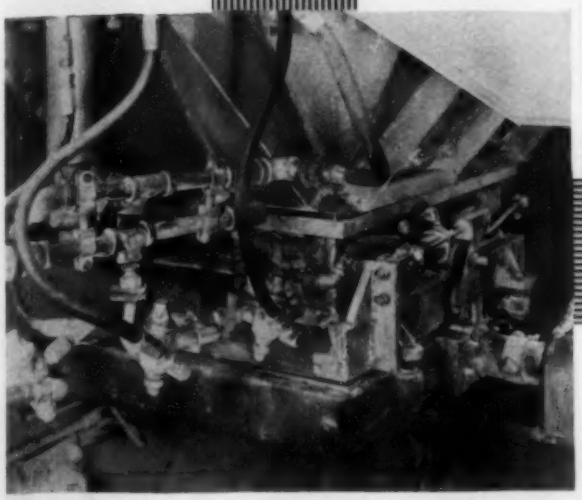


Fig. 2—Shell molds are prepared on four-station molding machine at right. After cores are set, cope and drag half of mold are joined by closing machine at left. Control panel for system is shown at lower right

A heated pattern consisting of the cope (top) half and drag (bottom) half of a mold is positioned beneath a water-jacketed hopper containing the sand-resin mixture. The patterns have been previously sprayed with a silicone lubricant for ease of pattern-shell separation at a later station. A measured volume of the sand mixture is released onto the pattern. Excess mixture is removed and reclaimed for further use by inverting the pattern. Shell and pat-





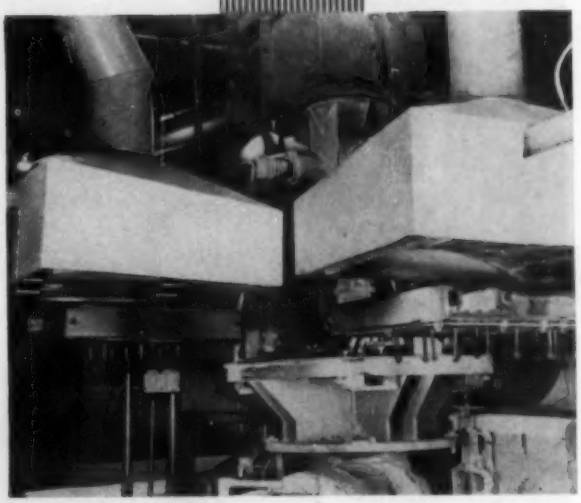


Fig. 3—Details of the shell molding machine in operation. Heated pattern is placed beneath hopper containing sand-resin mixture. Water-cooled flask is brought into contact with pattern and premeasured charge released. Excess sand and resin is dumped by automatic roll-over operation and recycled for further use. After the flask is withdrawn, the pattern moves through two successive infrared curing stations

▶ Many Advantages

The possible quantity production of molds is enhanced by the many advantages inherent in the shell form. Bonded sand produces a casting with a superior finish and improved dimensional accuracy which results in a reduction of finish machining costs. Thinner sections and more intricate designs can be produced. Smaller gates and risers mean an improved yield in pouring or conversely, a reduction in necessary melting capacity—an important point in casting more expensive alloys. The technical advantages and the improved flexibility of the overall operations are matched by the flexibility of the equipment. Electric controls permit a variation of

tern move through two infrared heat-curing stations where the proper hardness of shell is obtained. At the fourth station the pattern and mold are manually separated; the pattern is sprayed with the lubricant before being recycled. At a closing station, necessary cores are manually set in the drag half of the shell, a urea formaldehyde adhesive is brushed on and the cope half added to the lower part of the mold. A special closing machine accurately seals the two halves under controlled pneumatic pressure as the adhesive sets.

From this point the completed shell, ready for processing, can be stored until used or the mold can be placed on a trolley conveyor leading to the pouring station. If large stresses are indicated, shot, sand or gravel can be used to support a shell but normally small castings can be poured with the shell positioned horizontally on the conveyor platform without further preparation. Travel of the conveyor line can be adjusted to the cooling rate of the casting to allow for proper cooling prior to an automatic shakeout operation. The completed castings are then conveyed to the cleaning room.

Fig. 4 — Molds are transferred from storage point to overhead trolley conveyor for pouring. Sand, gravel or shot can be used to support the shell if necessary

pattern temperature, of investment and curing time and of the conveyor speed. Changes in patterns are easily made with a minimum of lost time. The total result is a cleaner more efficient production of a high quality casting.

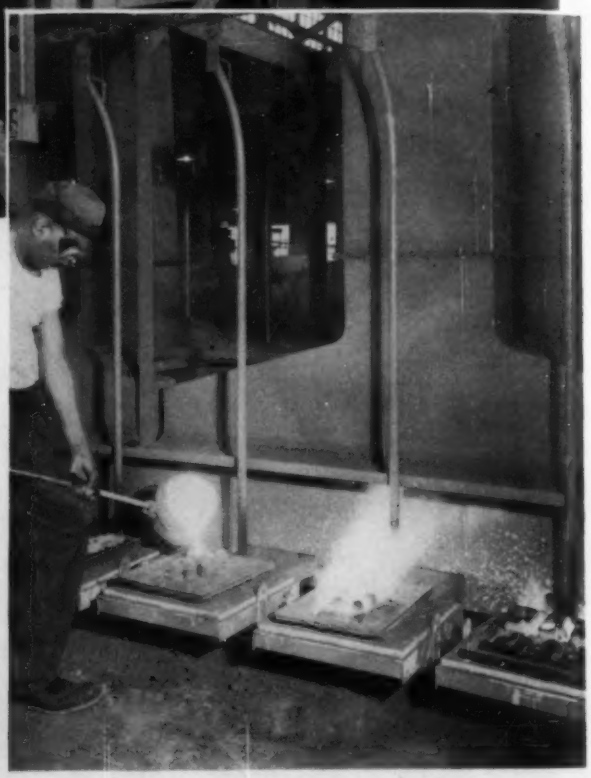


Fig. 5—Metal is poured into shell molds on moving trolley conveyor. Porous shells allow gas to escape which might otherwise be trapped in metal at cooling

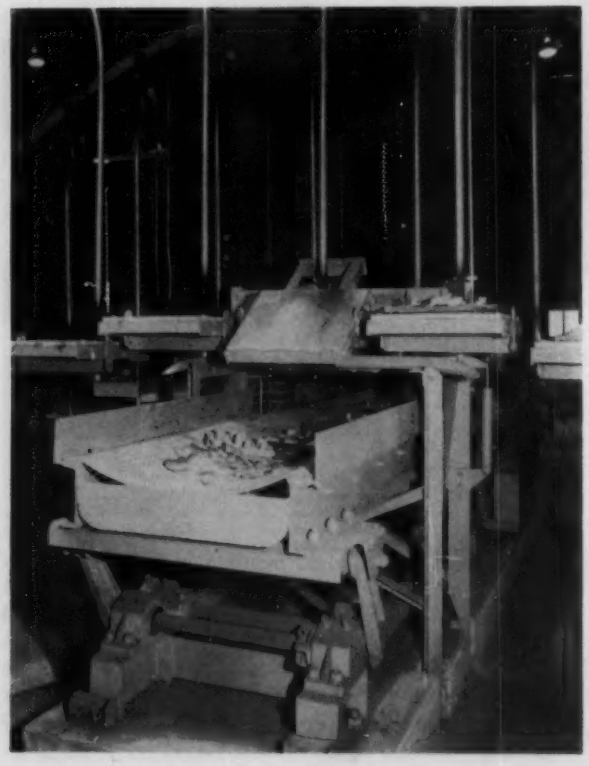


Fig. 6—Air operated mechanism trips conveyor pallet to dump shell mold and cooled casting into an oscillating conveyor. Sand falls through screen plate while castings are conveyed to cleaning room

RELAYS *discriminating* ~~most~~ engineers choose

Potter & Brumfield

"Your best source for relays" is Potter & Brumfield, because of an enviable reputation earned through a *quarter century* of relay specialization.

Millions of relays of *all styles* and *sizes* designed and manufactured to meet customer specification.

From small sub-miniature, precision, sensitive relays to heavy duty power types, each fulfilling an exacting requirement.

Enclosed hermetically sealed or open relay structures to meet demands of various environmental conditions.

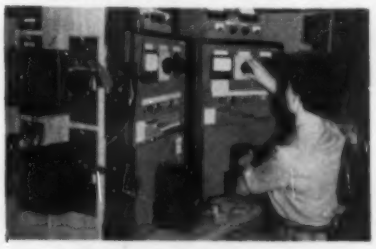
Priced competitively at all quality levels.

Samples available for immediate shipment. Send your specification for recommendations and quotations.

POTTER & BRUMFIELD MFG. CO., INC.
Princeton, Indiana

Another AMF Product
P&B Relays

Automatic Hi-Pot tester developed by P&B

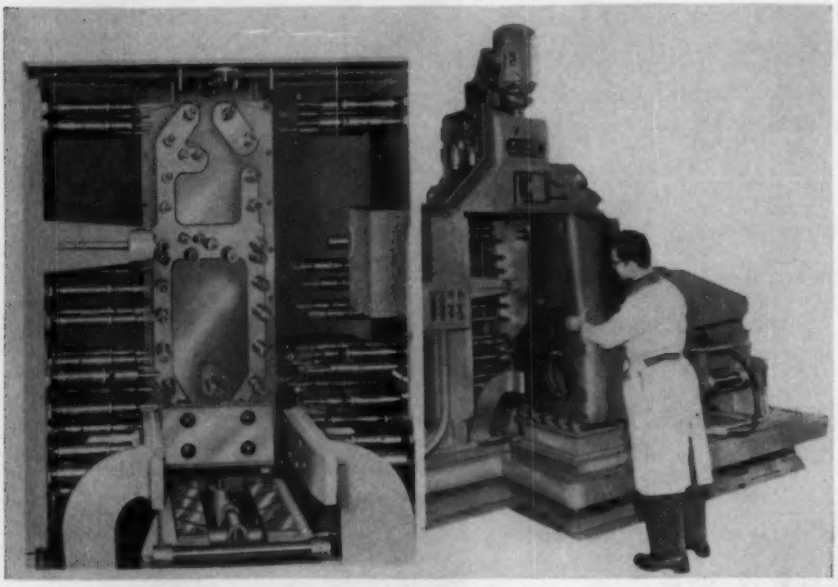


Ultrasonic Cleaning of relay assemblies

3D Microscopic Inspection and assembly

AUTOMATION new equipment

Machines and plant equipment designed for more automatic operations



AUTOMATIC TAPPER

Designed to tap holes in tractor transmission cases, new machine automatically taps 97 holes in all six sides of a transmission case in one cycle. Machine can complete the tapping operations on 40 crank cases per hour. Crankcase enters the machine from a roller conveyor. After the cycle switch is operated, locators align the crankcase, the crankcase is clamped, front tapping unit slides in front of the case and all tap spindles start rotating. Machine has six tapping units, one for each side of the crankcase. Front unit has 4 spindles; bottom unit, 10 spindles; right hand unit, 21 spindles; left hand unit, 22 spindles; top unit, 8 spindles; and rear unit, 32 spindles—a total of 97 spindles. All spindles are the individual lead screw and nut type, individually lubricated. Taps are lubricated by an independent coolant system. When tapping is completed, crankcase is automatically unclamped, the locators retract and the front tapping unit returns to its original position. **Michigan Drill Head Co.**, P.O. Box 4643, Detroit 34, Mich.

Circle No. **1** *on Reply Card*

TAPE PUNCHING UNITS

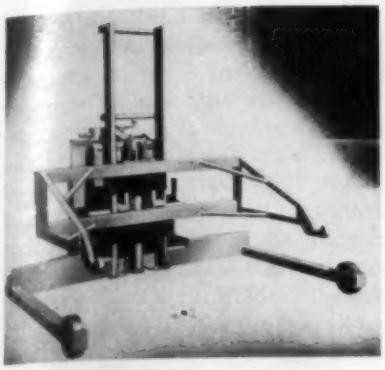
Twenty models of punched-tape adding machines and 14 models of punched tape bookkeeping machines have been added to line of office equipment. Bookkeeping machine automatically duplicates postings in a perforated tape which can be fed directly into other office machines such as the teletype, the tape-to-card punch or the Flexowriter. Tapes can be mailed to another location or stored and used over. Bookkeeper can operate with any 5, 6, 7 or 8-channel equipment. Also available are 9 to 14-column capacities for various accounting jobs. Bookkeeping machines perforate tape at the rate of 20 digits per second. Errors in the tape may be corrected instantly, and automatic interlocks prevent misoperation if a key is accidentally depressed. Auto-Punch adding machine operates as a regular full keyboard adding machine. Simultaneously with the printing of figures on standard adding machine paper or wide forms, it automatically punches and codes in 5, 6, 7, or 8-channel tape. Adder perforates at the rate of 1800 digits per minute. Automatic coding and error correction are among its features. Adders are available in any listing and totaling capacity from 10 to 14 columns, in narrow carriages for adding paper and forms up to 4¾ inches wide, or in wide carriages for forms up to 12 inches wide. **Monroe Calculating Machine Co. Inc.**, Orange, N. J.

Circle No. **2** *on Reply Card*

FORK LIFT TRUCK

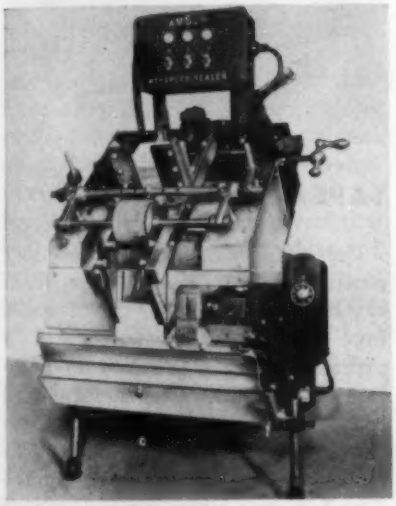
Electric fork lift truck was designed to solve a handling problem for an oilcloth and linoleum manufacturer. Unit will remove heavy rolls of felt from storage and place them on a coating machine ready for processing. Rolls are 42-inch diameter and 77-inch long and weigh over 3000 lb. Lifting height of the truck is 65 inches.

A shaft through the center of the roll fits into the notches of the forks, making transporting and lifting a one-man, one-truck operation. Linkage designed makes it possible to introduce two stabiliz-



ing casters under the load carrying frame of the truck. These two points of support distribute the weight over a wider base and increase stability under high, heavy loads. Straddle type truck is a stand-up end control design. **Lewis-Shepard Products Inc.,** Department R-12, Watertown, Mass.

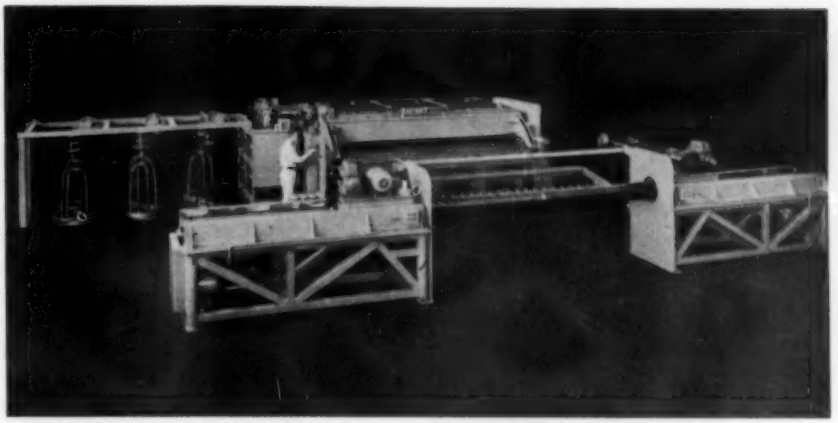
Circle No. **3** *on Reply Card*



BAG LABELER, SEALER

High speed unit uses casein to label and seal automatically all heat sealable bag materials. For nonheat sealable materials, thermoplastic label stock is used. Single handscrew adjustment permits instant changeover from one label size to another. Machine has attachments for positive hole punching, code dating and imprinting, and can be used for packaging operations requiring transparent films and labels for product identification and display treatment. **Amsco Packaging Machinery Inc.,** 31-31 48th Ave., Long Island City 1, N. Y.

Circle No. **4** *on Reply Card*



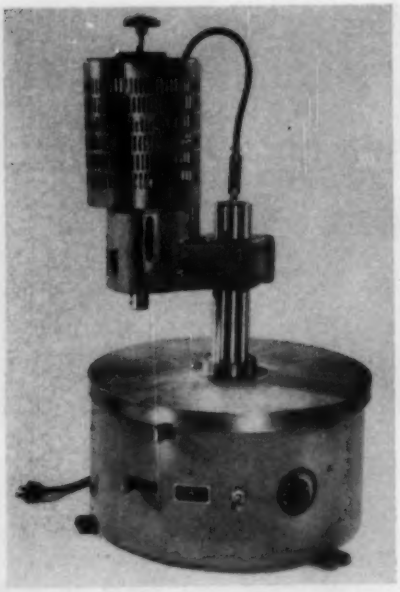
WIRE MESH WELDING MACHINE

Mechanically operated, high speed resistance welding machine produces wire mesh up to 13 ft wide from coiled steel wire in a continuous operation. Machine will fabricate mesh from 4 to 14 gage wire at a rate of 60 cross wires per minute. Operating flexibility is provided in the machine, which will handle up to 79 longitudinal wires with a wire spacing from 2 inches up. Cross wires can be spaced from 2 to 12 inches. Machine will produce wire mesh in either square or rectangular patterns as desired. High speed operation is accomplished by feeding six cross wires at a time, cutting them off and conveying them to a hopper from which they are fed, one at a time, to a resistance welding crosshead upon which up to 79 individual spring loaded welding guns are mounted. This multiple cross wire feed unit is designed for use on heavy gage cross wires up to ⅜-inch diameter. Where light gage wire is used, a single wire cross wire feed is provided. Mesh welder consists of five units: a longitudinal wire straightener, a multiple crosswire feed, a straightener and cutoff machine, a resistance welding crosshead, a slitter and a coiler. Machine is mechanically operated. One main shaft, driven by a 15-hp motor and speed reducer combination, controls all of the functions of longitudinal wire indexing, crosswire hopper operation and welder crosshead operation through eccentrics and toggle linkages. All gun units are grounded to a shunting bar. The lower electrodes in the welder unit are connected to secondary transformer leads so that two series welds are made through two adjacent guns. Guns are individually adjusted transversely. The crosswire feed, straightener and cutoff units have several motor drives. Three 5-hp motors power the arbor type straighteners, each motor driving two arbors. Two sets of drive rolls are provided for each wire—one set ahead of each arbor and one behind it. A 15-hp motor powers all drive rolls. Crosswire cutoff mechanism is an eccentric and crank type driven by a 3-hp motor through an electric clutch and brake unit. A 1-hp motor powers the five screw conveyors that advance the cutoff wires to the hopper. The coiler has two 10-inch diameter mandrels that pilot into each other. Mandrels are powered by 5-hp motor and speed reducer units. Machine and its accessories are approximately 7 ft high and occupy a floor space approximately 35 ft by 32 ft. **Expert Welding Machine Div.,** 17144 Mt. Elliott Ave., Detroit 12, Mich.

Circle No. **5** *on Reply Card*

INDEXING TABLE

Feature of new electric indexing table for automatic work positioning is a central column on which tools can be mounted. Table is available both as a packaged unit with the company's electric impact hammer which stakes, rivets, or marks automatically with the cycling of the table, or separately, for use with other automatic tools. Built-in automatic timer in the



self-contained table is continuously adjustable from 6 to 54 indices per minute and automatically triggers the tools when the table locks in position. A 1/20-hp gearhead motor, running continuously, furnishes the power. The automatic timer triggers a solenoid that operates a clutch on a cam. With each rotation of this cam, a nylon roller advances the table one station. The 15-inch table is locked by a ground pin engaging hardened, tapered bushings set in the table. Repeat accuracy is 0.001-inch. Table will take eight 3¾-inch diameter station fixtures. **Black & Webster Inc.**, 445 Watertown St., Newton 58, Mass.

Circle No. **6** *on Reply Card*

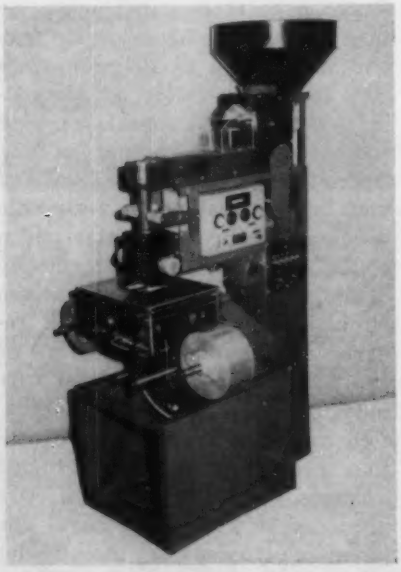
ELECTRONIC RECORDER

Designed to keep perpetual inventory and record withdrawals and sales without the use of cards, tape, or other external media, electronic recorder can be used in any business organization needing inventory records on a day to day or hour to hour basis. Device can be used as a point-of-sales recorder. For example, in a department store, it can be used to maintain complete inventory information on 10,000 different items. It reads a tag which the sales clerk has removed from the item just sold, completely identifying the item. Recorder then figures out the total price for the quantity just purchased, adds federal and local taxes and finally typewrites automatically a complete sales slip bearing all pertinent information. Device also computes and remembers the number of items remaining in stock after substracting the sale, the sales clerk's dollar sales volume and the items which must be reordered. It prints information at the end of the day covering the entire inventory of a selected list of active items. Other business accounting functions performed by the unit are payroll accounting, sales analysis and production scheduling. Electronic recorder is completely self-contained and requires no auxiliary equipment. **Business Machines Div., Electronics Corp. of America,** 10 Potter St., Cambridge 42, Mass.

Circle No. **7** *on Reply Card*

PACKAGING MACHINE

New machine automatically counts and cellophane wraps predetermined number of small parts, pharmaceuticals, hardware or other items. Feeding and counting portion of machine is available without the heat sealing wrapper if another type of container is desired. Feeding rate of the machine is 120 ft per minute. Changeover from one item to another does not require additional tracks or other equipment. Machine can also be used for bulk or small quantity counting in shipping departments or inventory counting. **Delta Engineering Corp.,** 88 Broad St., Boston 10, Mass.

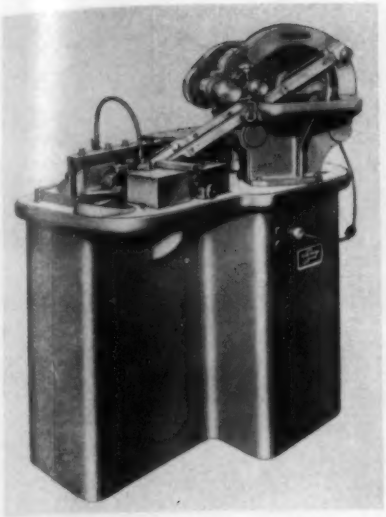


Circle No. **8** *on Reply Card*

TAPE CONVERTER

Converter operates an X-Y plotter from a punched tape reader, but can also be run from a tape actuated typewriter if a printed listing is desired in addition to the plot. For the standard converter, the tape is punched in the five-hole communications code. Nine symbols are required on the tape for each point plotted; a sign and three digits for each co-ordinate, and a tab or carriage return which initiates the plotting of the point. The tape reader normally operates at ten symbols per second, and the plotter requires one second to travel full diagonal. Therefore, plotting proceeds at a rate of from one to two seconds per point, depending on the point spacing. Maximum power used from the 115v supply is 75va because all except one of the 42 tubes in the converter are cold cathode gas tubes. The punched tape converter measures 10½ inches by 19 inches by 12 inches in a case or rack mount, and weighs 42 lb. **Librascope Inc.,** 1607 Flower St., Glendale, Calif.

Circle No. **9** *on Reply Card*



THREAD ROLLER

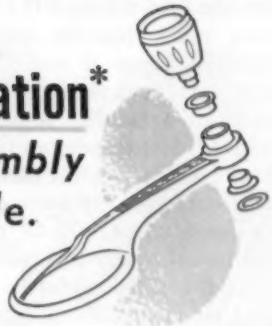
Thread rolling machine features a new feeding system which employs a rotary type hopper. Production rate of the unit is 230 to 250 pieces per minute. Feed rails have been lengthened to accommodate more pieces, and to provide more time for the feed clearing wheel to reject imperfect blanks which clog the feed rail. Power from a 1/12-hp motor drives the hopper independently, permitting variable bucket speeds by changing gears. Hopper bucket is made of cast iron and lifts out for servicing. Clearing wheel is mounted on a bracket which swings away from the tracks for easy inspection and replacement. Screw diameter capacity runs from machine screw size No. 2 to No. 10. Thread length capacity of the machine is ⅛ to 1½ inches with standard depth dies, and 2 inches with special depth dies. Flat type dies are used with the machine. **Hartford Special Machinery Co.**, 287 Homestead Ave., Hartford 12, Conn.

Circle No. **10** *on Reply Card*

SPINDLE TAPPER

New device is designed for direct spindle tapping without the use of tapping heads or clutches. Tapper consists of a drill unit with a special, inline mounted motor for 220 to 440v, three-phase operation. Standard shaft speed is 1140 rpm, with other speeds available. Unit is furnished with a motor control cabinet containing a magnetic motor reversing contactor, line over-

...that's what
AEL Packaged Automation*
achieved for the assembly of this window handle.



Before AEL Automation:
24 workers + former methods = 2,900 units per hour @ 1¢ each

After AEL Automation:
4 workers + AEL = 6,000 units per hour @ 1/10¢ each

***WHAT IS AEL PACKAGED AUTOMATION?**

Automation Engineering Laboratory *designs, engineers* and *builds* your equipment... is a single source of responsibility to handle the *entire job* of automating your production process. AEL will—

- **Make engineering study of the job to be done**
- **Submit firm proposal to supply automatic equipment at a *fixed price*, guaranteed to perform in accordance with specifications**
- ***Design* and *build* complete automated unit or system**
- **Run test for client before delivery**

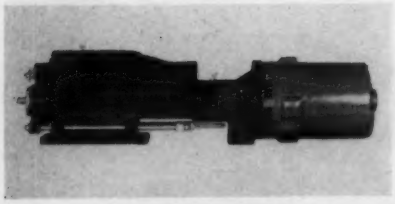
WILL AUTOMATION WORK FOR YOU?

If your product requires fabrication, assembly, packaging or feeding—if you have a repetitive operation that takes the full time of one or more workers—*AEL Packaged Automation* can very likely boost your output, cut your production cost.

AEL engineers want to help you explore—without obligation—the possibilities of *AEL Packaged Automation* for your plant. Write or phone for further information.

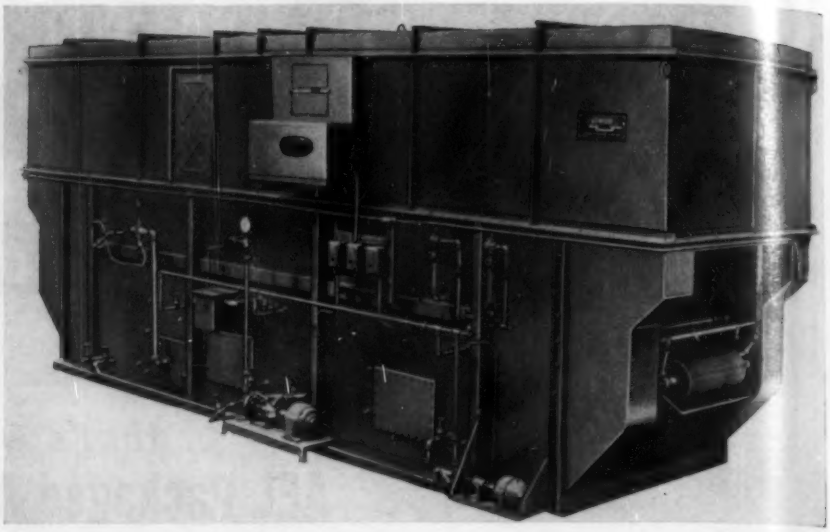
COPYRIGHT 1955 AEL

AUTOMATION ENGINEERING LABORATORY
Greenwich 8-2300
One East Putnam Avenue • Greenwich, Connecticut



load protection, control transformer and terminal strip. The control transformer delivers 115v, single-phase power for all control circuits. Tapper features rapid air-powered approach to the work and hydraulic feed through the work at pre-set rate. Spindle traverse is adjustable from 0 to 3 inches; thrust is approximately three times applied air pressure. A broad differential in advance and retract piston areas provides thrust step down for proper tap back out. Tap sizes range up to 5/16-18, or ⅜-24 in mild steel. Any tap holder that will fit the spindle tapper may be used. Unit is capable of continuous duty at rates up to 60 reversals per minute. Tapper may be mounted at any angle. **Bellows Co.**, Akron 9, O.

Circle No. **11** *on Reply Card*



ULTRASONIC DEGREASERS

New ultrasonic metal degreasing equipment features transducers to generate low ultrasonic frequencies which have high penetrating ability and therefore greater cleaning efficiency. In this equipment, low frequency ultrasonic waves, generated by barium titanate transducers, curve around corners and sharp angles, penetrate into recesses and capillaries to remove dirt, oil, grease, chips and lapping compound from the article to be cleaned. Flat shape of the transducers permits them to be teamed to any length or width for cleaning large shapes such as transmission pumps and gears. Because sound energy is beamed over a wide area, small parts like bearings and electronic components can be cleaned ultrasonically without requiring critical positioning. As the transducers expand and contract under electrical excitation, the resulting ultrasonic energy causes severe cavitation in the surrounding cleaning solution, usually trichlorethylene or perchlorethylene. The cavitation cleans the metal parts by subjecting them to a rapid scrubbing action. Design of the barium titanate crystal transducers permits them to be driven at high watt densities, so that sound waves need not be focused to produce adequate intensity of cavitation. Transducers are available in 500w, 2kw, 10kw and 25kw ultrasonic units, each comprising an ultrasonic generator and an ultrasonic chamber. Units are available separately or integrated with vapor degreasers. Ultrasonic chambers may also be integrated into existing degreasing machines with liquid immersion stages. **Circo Equipment Co.**, 138 Central Ave., Clark (Rahway), N. J.

Circle No. **12** *on Reply Card*

tomorrow's OPPORTUNITY today

for experienced

ELECTRONIC ENGINEERS

and

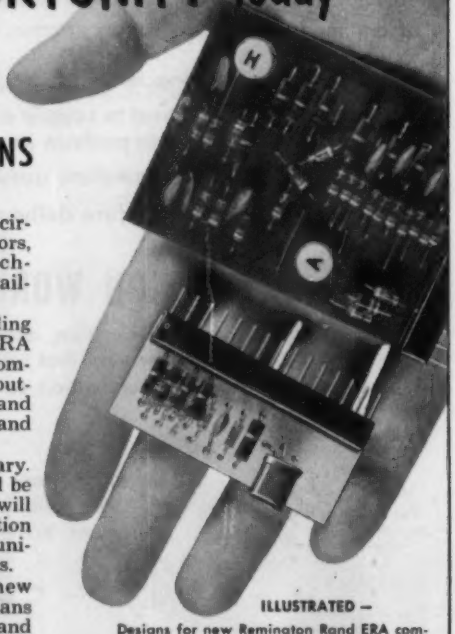
ELECTRONIC TECHNICIANS

If you can develop new computer circuits using magnetic cores, transistors, printed wiring, and other new techniques, we have a good position available for you.

You will work with the outstanding computer men who developed the ERA 1101, ERA 1102, and ERA 1103 Computer Systems, the Univac File Computer, ERA magnetic drum memories, and other equally famous Remington Rand systems.

Computer experience is not necessary. Your proficiency in related fields will be rewarded from the start, and you will work in the fastest-growing organization in the data-processing field. Opportunities for advancement will be numerous.

Positions are also available for new engineering graduates and technicians who want to learn digital techniques and systems. Pay, special benefits, and opportunities for advancement are most attractive.



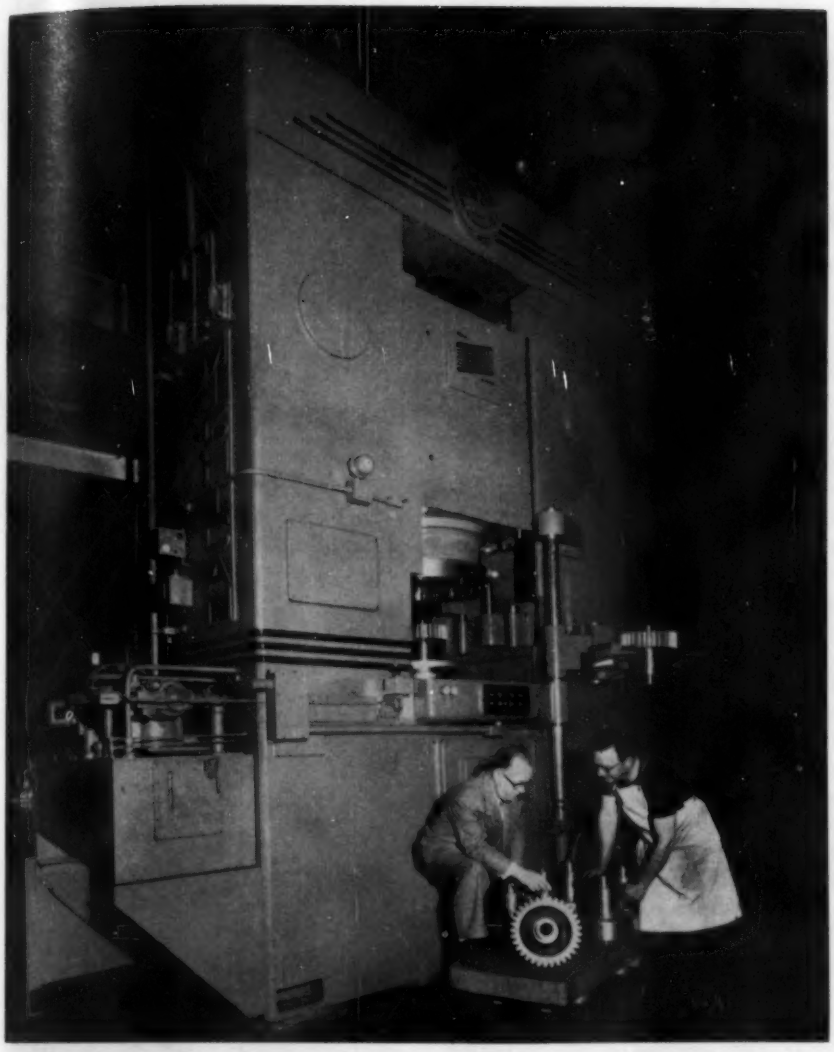
ILLUSTRATED —
Designs for new Remington Rand ERA computers that are now under development. *Upper:* general purpose digit register. *Lower:* packaged transistor logic element.

Please send an outline of your training and experience to Mr. J. N. Woodbury:

Remington Rand

ENGINEERING RESEARCH ASSOCIATES DIVISION

1902 W. Minnehaha Ave. • St. Paul W4, Minnesota



SHAPING MACHINES

Designed for cutting gears up to 20-inch diameter and toothed parts, these new shaping machines weigh over 44 tons and are more than 17 ft high. One of the features of the machine is an automatic hydraulic positioning hoist, used to swing the cutting head into position for mounting in the machine, and also to load and unload part blanks that weigh up to several hundred pounds. Hydraulic, electrical and drive components are located so that they are either exposed, or can be exposed for adjustment and maintenance. Chip conveyor in the machine carries away the large volume of metal chips removed from a part in one production cycle. Three automatic pressure lubricating systems feed a continuous flow of oil to all moving parts. One network lubricates all the working components of the head, such as cams, shafts, bearing surfaces, etc.

Another one keeps the two gear sets in the drive section oiled. The third system lubricates the moving components of the reciprocating work ram—the connecting rod, wrist pin and bearings. A special detecting system warning bell notifies the operator if the ram section is not receiving the proper lubrication. Either hydraulic or pneumatic clamping fixtures can be used on the machines. Cutting heads are interchangeable to accommodate different part sizes and shapes. Stroke of the reciprocating work ram is adjustable to the face widths of the gears, cams, etc. being cut. **Michigan Tool Co.**, 7171 E. McNichols Rd., Detroit 12, Mich.

Circle No. **13** *on Reply Card*

HERE'S HOW YOU CAN TELL

THE KEYSTONE 3-POSITION INDICATOR gives you information on plant operation conditions right where you want it: in your office! Originally developed for aircraft use, it is simple, easy to read, hermetically sealed, reliable. Gives *yes no, on-off, high-low* answer at a glance, swiftly, conveniently, surely. Adaptable to both AC and DC over wide range. Send coupon for complete information.

KEYSTONE WATCH CASE & INSTRUMENT DIV.

HKP

H. K. PORTER COMPANY, INC.

THE RIVERSIDE METAL COMPANY

RIVERSIDE, N. J.

KEYSTONE WATCH CASE & INSTRUMENT DIV.
Riverside, N. J. Dept. 4

Please send info. and specifications on 3-position indicator. Application I have in mind is_____

Name_____

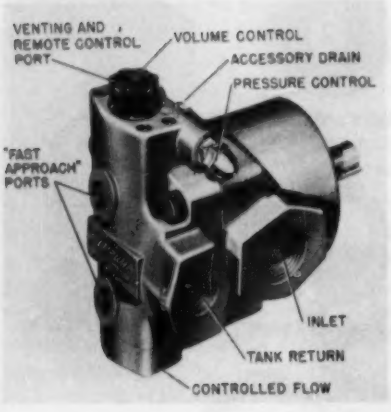
Firm_____

Address_____

City_____ State_____

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems



Variable Volume Vane Pump

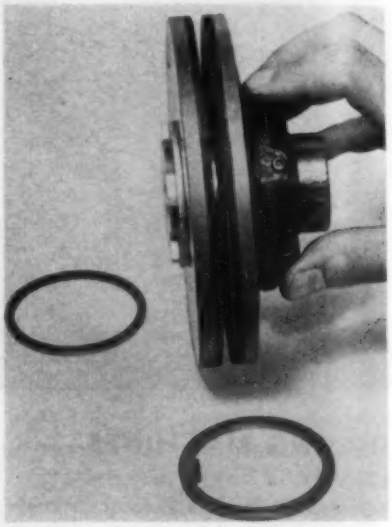
Called the Multipump, new vane pump will deliver variable volume at constant speed, or constant volume at variable speed. Pump features finger tip volume control which works independently of compensator and compensator control that works at all volumes. A stop for minimum volume is available. Multipump holds volume within ±5 per cent over desired pressure and designed speed ranges. It delivers preset volume and preset pressure to the system. Addition of on-off valve provides requirements for cylinder control. Multipump can be used where constant volume pumps are used and a need exists for varying the volume, where piston or gear pumps are used for pressures up to 1000 psi continuously, where systems that call for high and low volume are served by double pumps, and where volume must be held constant while changing pump speed. Unit saves horsepower by delivering only the oil needed by the hydraulic circuit. Excess volume is delivered to the tank at low pressure. Less cooling is needed because as pump delivery is reduced, horsepower input is reduced. In addition, there is a cooling flow circulated through the pump at all times so that the pump operates at reservoir temperatures. Power from a single variable speed engine may be used to provide constant speed accessory drives. Double sealing edges keep internal slippage low. Inner and outer ends of the vane are exposed to identical pressures, maintaining radial balance at all times, thus preventing excessive wear on cam rings. Multipump is available in three sizes, rated 5, 15 and 25 gpm at 1200 rpm. **Denison Engineering Co.,** Columbus, O.

Circle No. **14** *on Reply Card*

Cushion Conveyor Rollers

Neoprene rollers provide cushioned rides for finished stampings, panels, glass, plexiglass, stainless steel and other materials. Rollers are molded to provide even density throughout. Five rollers of varying design and density are available for use on die lifters, hydromatic welders and gravity roll conveyors, as well as idlers on belt conveyors. Parts and mountings are interchangeable. **Stilson Tool Inc.,** 30233 Groesbeck Highway, Roseville, Mich.

Circle No. **15** *on Reply Card*



Torque Limiters

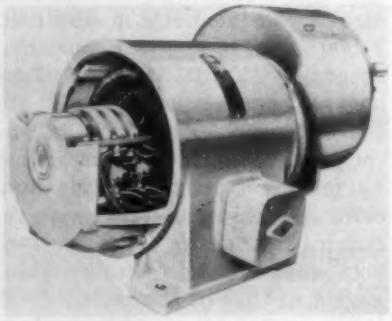
Line of machinery drive overload protection devices features high friction, wearproof friction disks and an adjusting nut locking arrangement. Torque limiters are slip type friction clutch devices upon which such drive components as plain plate roller chain sprockets, V-belt pulleys or gears can be mounted. Torque limiters are used on conveyors, agricultural equipment, automated machine tools, materials handling equipment, packaging machinery and machinery drives where overload protection is needed. **Morse Chain Co.,** 7601 Central Ave., Detroit 10, Mich.

Circle No. **16** *on Reply Card*

Wiring Duct

New wiring duct is of all plastic construction and has only two parts—a one-piece, U-shaped channel and polystyrene plastic covers. Channel is of laminated phenolic resin. Covers can be removed for maintenance or wiring changes. By compressing sides of channel, covers snap on or off. Wire lead out slots are angled and designed to allow passage of wires with connectors and wire groupings. Wiring duct is available in sizes ranging from 1 by 1 inch to 3 by 3 inches. **Stahlin Bros. Fibre Works Inc.**, Belding, Mich.

Circle No. **17** *on Reply Card*



Slip Ring Motor Reducer

Used on cranes, hoists, fans, printing presses, lathes, crushers and centrifugals, slip ring offset shaft motor reducer features ability to provide variable speed reduction and high starting torque on low starting current. Offset shaft of reducer can be hooked up at 3, 6, 9 and 12 o'clock positions. This factor, along with the standard dimensions of the slip ring drive motor provide space saving when used in close quarters. Motor reducers are available in ratings from ½ through 5 hp, and in speed reductions of 520 through 16 rpm. Units are also available with double reduction gear reducers and various combinations using a magnetic brake. Drive motor may be either drip proof or totally enclosed. Slip ring motors are also available separately in ratings from ½ through 15 hp. **Reuland Electric Co.**, Alhambra, Calif.

Circle No. **18** *on Reply Card*

Expanded Scale Voltmeters

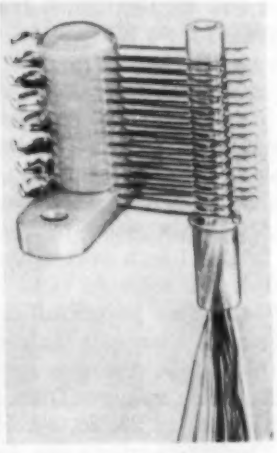
Designed for panel mounting, line of expanded scale voltmeters are accurate to ½ per cent of input voltage and offer a linear scale which includes only the useful portion of the scale. Standard base voltages range from 6.25 to 230v, with span that can vary from 4 to 25 per cent of base voltage. Hermetically sealed models meet military specifications for environmental conditions. Models 2½ and 3½-inches round or square, or 4½-inches round and 4 by 6-inches rectangular are available. **Arga Div., Beckman Instruments Inc.**, 220 Pasadena Ave., S. Pasadena, Calif.

Circle No. **19** *on Reply Card*

Rotary Hopper Parts Feeder

New rotary hopper, designed to provide accurate, high speed parts delivery to machine tools; feeds parts to presses, grinders, special machines and machine tools; and can also be used for sorting, counting, and inspection operations. Unit operates by means of a fully enclosed, continuous duty motor, and has a slip clutch for overloads. Clutch is easily accessible for adjustment. Twelve-pitch gears, mounted on ball bearing shafts, are used throughout for continuous, heavy duty performance. All gears and bearings operate in an oil bath. Rotary hopper incorporates a three-point mounting in the base, for installation on rough or uneven surfaces. Hopper can be supplied with up to four separate feeding tracks. **Feedmatic Inc.**, 22515 Telegraph Rd., Detroit 19, Mich.

Circle No. **20** *on Reply Card*



Slip Ring and Brush Assemblies

Miniature slip ring and brush assemblies are designed to transmit electrical energy to and from rotating elements in various kinds of electromechanical devices. Among their uses are in computers, telemeters, and other types of electronic control and indicating systems. Units are said to be well suited for applications such as gyroscopes where low friction and high precision are required. Assemblies are engineered to provide minimum of resistance to rotation of parts to which the slip rings are attached. Rings may be finished to 4 or 5-microinch surface if desired. Rings are turned from silver, sterling silver, coin silver, gold, platinum, or alloys. Lead wires are soldered to the rings. Corrosion resistant, precious metals or alloys are used for brushes.

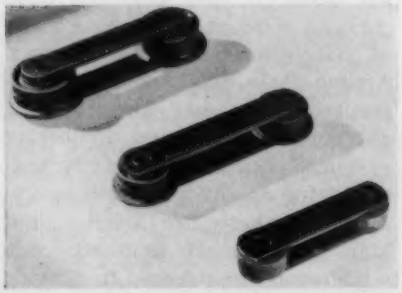
Custom built to application specifications, they are designed to retain positive contact pressure. Metal wipers are permanently attached to solder lugs. **Electronics Div., Iron Fireman Mfg. Co.,** 2838 S.E. Ninth Ave., Portland, Oreg.

Circle No. **21** *on Reply Card*

Solenoid Air Valve

Line of solenoid valve piloted air valves has been extended from ⅛, ¼ and ⅜-inch NPT sizes to include models for ½, ¾ and 1-inch NPT sizes. Air valve is capable of high actuation rates and has the ability to operate on short electrical signals. Single solenoid valve measures less than 11-inches long and 5½-inches wide by 4-inches high in the 1-inch port size. Illustrated double solenoid valve is less than 14 inches in overall length. Three and four-way valves are available for dc voltages from 1.4 to 475 and ac voltages from 3.6 to 750 in cycles of 25, 30, 40, 50 and 60. Electrical outlets are ½-inch NPT conduit. **Beckett-Harcum Co.,** Wayne Rd., Wilmington, O.

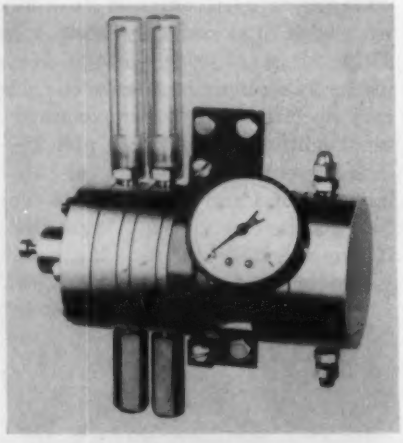
Circle No. **22** *on Reply Card*



Side Chain for Conveyors

Designed for use with hinged steel conveyor belting, side chain is available in 2½, 6 and 9-inch pitches. Working load capacities range from 1250 lb per strand for the 2½-inch pitch size up to 6750 lb per strand for the 9-inch pitch size. Chain also can be used for applications including slat or apron conveyors and drag and open type chain conveyors. Small 6-inch unit has side bars ¼ by 1¾ inches, and 2½-inch diameter rollers which are made of special alloy cast iron. Same pitch size can be furnished with 3-inch diameter straight faced rollers and with ¼ by 2-inch high-carbon steel side bars. Rollers are available with single flange if desired. With the large side bars, chain features working load capacity of 4500 lb per strand. The 9-inch pitch units are equipped with single flanged rollers. Working load of this unit is also 4500 lb per strand. Heaviest chain, shown at top, is 9 inches pitch. This chain with its low coefficient of friction and working load of 6750 lb per strand is used on installations up to 1500 ft long. **May-Fran Engineering Inc.,** 1761 Clarkstone Rd., Cleveland 12, O.

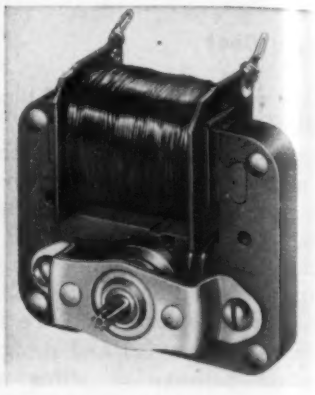
Circle No. **23** *on Reply Card*



Pneumatic Transmitter

Designed for measuring flow, level, and differential pressures in water filtration and sewage plants, and for low pressure industrial service, pneumatic transmitter operates on force balance principle. Transmitter delivers a pneumatic output pressure in which changes are exactly proportional to changes in loading pressures. Output may be a direct or inverse function of single loading pressure or of the difference or sum of more than one loading pressure. Small diameter tubing between the transmitter and the remote instrument conveys the pneumatic signal which actuates the instrument mechanism. Transmitter has a minimum output pressure of 3 psi and has no zero drift when static pressure changes or air pressure is shut off. **Builders-Providence Inc.,** 345 Harris Ave., Providence, R. I.

Circle No. **24** *on Reply Card*



Fractional Horsepower Motors

Line of skeleton type and clutch gear type fractional horsepower motors features high starting torque and simplified mounting. Skeleton type motors are two-pole, shaded pole, available in sizes from 1/500 to 1/25-hp, with operating speeds of 2100 to 3500 rpm. Voltage range is 6v ac to 220v ac, 50 or 60 cycle. Maximum inch-oz torque is 14 inch-oz running and 10 inch-oz starting. Models have clockwise or counterclockwise rotation. Clutch-gear types are two-pole, shaded pole, featuring disengagement time of approximately 25 milliseconds. They are available in speeds from 4 to 328 rpm. These motors can be used in business machines, displays, signal lights, coin operated games and vendors, mixers, remote controls, width gages, blowers, freezers, recorders, electric scoreboards and toys. **Comar Electric Co.,** 3349 Addison St., Chicago 18, Ill.

Circle No. **25** *on Reply Card*

Back Pressure Regulator

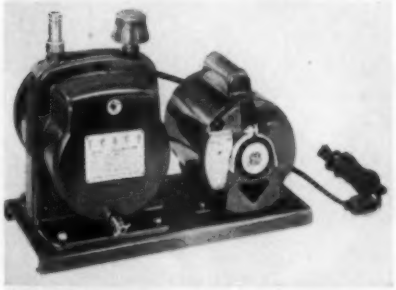
Designed for control on low pressure oil separators, water knockouts, gunbarrels, gas gathering lines and other equipment requiring close pressure control as well as tight shutoff, back pressure regulator works equally well, within its pressure limitations, in

all gas or air services that require back pressure regulation. Integral controller provides close sensitivity to pressure fluctuations. Construction features include a cast iron valve body, spring housing and diaphragm casings, pressure transmission tube, and pilot operating mechanism machined from stainless steel and aluminum. Regulator is said to operate with a minimum of dissipation of the gas or air used in the controller. Unit is available in 2-inch screwed globe, 3 and 4-inch flanged globe sizes; its control range is 5 to 125 lb, temperature range up to 165F. **Black, Sivalls & Bryson Inc.,** 7500 E. 12th St., Kansas City 26, Mo.

Circle No. **26** *on Reply Card*

Mechanical Vacuum Pumps

Line of mechanical vacuum pumps features quiet operation with very little vibration. New pumps feature high pumping capacity per cu ft of space. Pumps produce a free air displacement of 70 liters per minute and a guaranteed ultimate vacuum of 0.1 micron. Its



floor space requirement is 8½ by 17½-inches with an overall height of approximately 13 inches. Unit pumps from atmospheric pressure to ultimate pressure in less than 5 minutes. Pumps are available in models with ⅓-hp motor for 115 to 230v, 60 or 50 cycles, or 220 to 440 three-phase, 50 to 60 cycles, and with explosion proof motor. **Central Scientific Co.,** 1700 Irving Park Rd., Chicago, Ill.

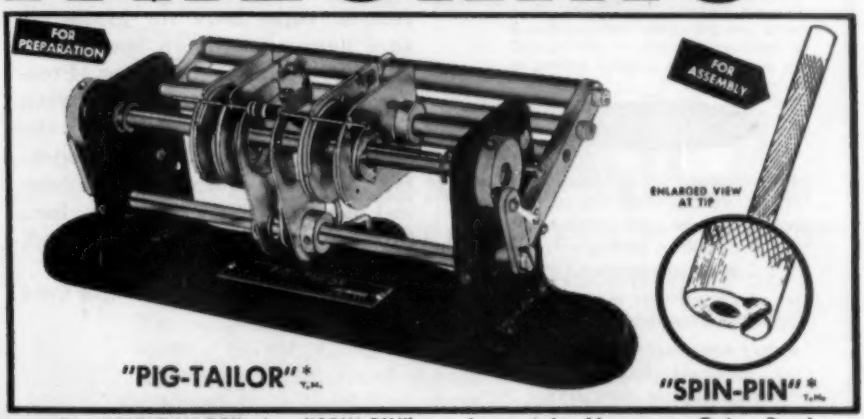
Circle No. **27** *on Reply Card*

Vacuum Gage Tube

Designed to retain permanent calibration while withstanding vibration, shock and temperature change, vacuum gage tube is used with company vacuum gage and vacuum indicator control in the 1 to 1000 micron range. Sensing elements of gage tube are short, butt welded metal thermocouples

"PIG-TAILORING"

. . . . a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.



The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

* PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. A7-P

BRUNO-NEW YORK INDUSTRIES CORPORATION

DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT

460 WEST 34th STREET • NEW YORK 1, N. Y.

transistor & digital computer techniques

APPLIED TO THE DESIGN, DEVELOPMENT AND APPLICATION OF

AUTOMATIC RADAR DATA PROCESSING, TRANSMISSION AND CORRELATION IN LARGE GROUND NETWORKS

Engineers & Physicists

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in fields listed, or with exceptional ability, are invited to consider joining us.

FIELDS INCLUDE

TRANSISTOR CIRCUITS
DIGITAL COMPUTING NETS
MAGNETIC DRUM AND CORE MEMORY
LOGICAL DESIGN
PROGRAMMING
VERY HIGH POWER MODULATORS AND TRANSMITTERS
INPUT AND OUTPUT DEVICES
SPECIAL DISPLAYS
MICROWAVE CIRCUITS

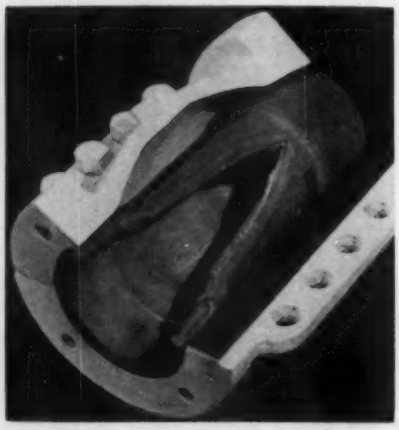
Scientific and Engineering Staff

HUGHES
RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

which are arranged in a thermopile to compensate for temperature changes. Gage tubes have response of ½ second. **Hastings Instrument Co. Inc.**, Hampton, Va.

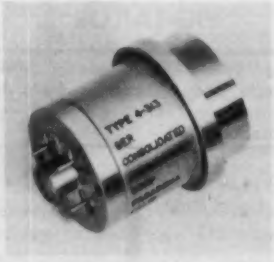
Circle No. **28** *on Reply Card*



Control Valve

Handling solids in suspension, acid slurries, and bulky materials are among applications of flow control valve. Can be operated either pneumatically or hydraulically for throttling or on-off service. Valve body is cast iron; sleeve is pure gum rubber, butyl or neoprene reinforced with multiply cords. Impulse from instrument can be direct to valve body for low pressure lines, or through booster relay for high pressure lines. Pressure in the annular space between the body and sleeve compresses the sleeve, thus varying the valve opening. Does not require large mechanical operator. **Red Jacket Co., Inc.**, 510 Investment Bldg., Pittsburgh 22, Pa.

Circle No. **29** *on Reply Card*



Miniature Pressure Pickups

Two electrical resistance type pressure pickups are designed to measure gas and liquid pressures in the higher ranges desired for petroleum field work, chemical plants, and missile testing. Miniature pickups are available in gage and absolute models which feature high corrosion resistance and a flush type diaphragm. Illustrated model is designed for general purpose measurements and provides for flange type mountings; other type is supplied with a threaded case for hydraulic system applications where it is desirable to have the diaphragm flush with the liquid. Pickups are available in 1000, 2000, 3000, and 5000 psi gage and absolute ranges. Each pickup weighs approximately 50 grams. Unit incorporates a four-arm bridge to convert changes in diaphragm pressure to proportional changes in voltage output. This output can be permanently recorded with an oscillograph or observed visually on an oscilloscope or meter. **Consolidated Engineering Corp.**, 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle No. **30** *on Reply Card*

Automatic Reset Timer

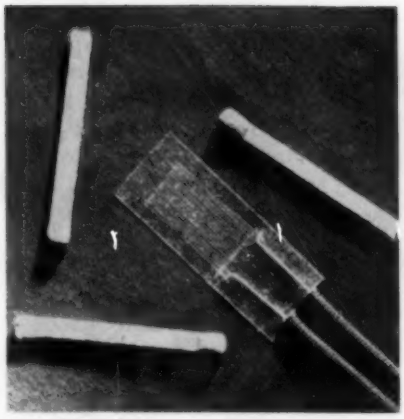
Among applications of automatic reset timer are vacuum metallizing, bonderizing, photography, honing, lapping, grinding, die casting, injection molding, sand mulling, hot dimpling, radiology, chemical feed proportioning, radiation counting, automatic lubrication, automatic batching and automatic scales. Timer has one piece injection molded acrylic front piece, serving dual purpose of dust proof cover and seal for dial. Expansion nut assembly fastens cover securely from rear surface and simplifies removal of dial. Timer mounts into single round cutout 3-3/16-inches diameter and is secured in place by tension studs on back up ring held in

position by O-ring retainer. Timer can be installed into panels up to ½-inch thick. Self-cleaning contacts, interchangeable in the field, are rated at 10 amp at 115v ac noninductive. All timing ranges use the same internal operating mechanism, housed in basic chassis and cover, with interchangeable dials and motors making possible 10 timing ranges from 0 to 15 seconds with minimum setting of ¼-second, to 0 to 240 minutes with minimum setting of 240 seconds. **Automatic Temperature Control Co. Inc.**, 5200 Pulaski Ave., Philadelphia 44, Pa.

Circle No. **31** *on Reply Card*

Resistance Thermometer Element

Line of resistance thermometer elements has been designed for higher temperature applications. Temperature sensitive grid of fine nickel wire is bonded between two thin pieces of insulating material. Silicone impregnated glass fiber fabric used in the unit permits continuous operation at 500F and short term use at 600F. Change



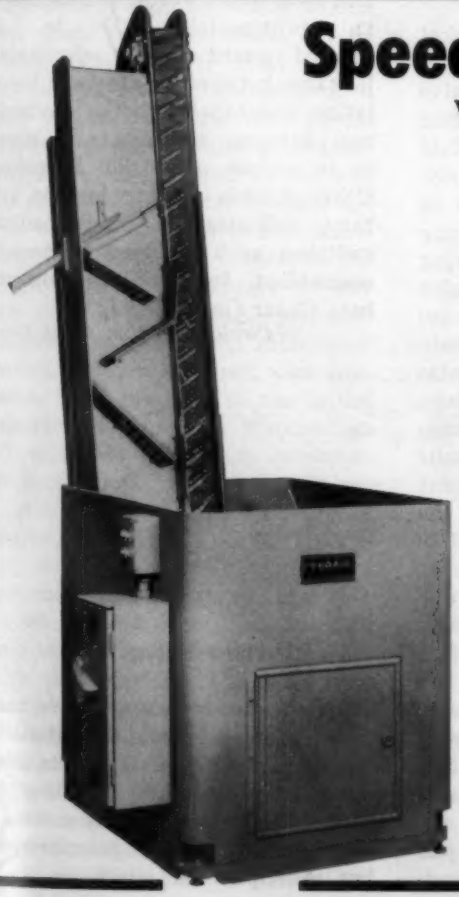
in resistance with temperature may be used to actuate direct reading indicators, recorders or controllers of various types. Temperature may also be determined by direct measurement of the element resistance by means of a Wheatstone bridge. Weight of the resistance thermometer element excluding external leads is approximately 2 grains. At 70F the resistance of the unit is 100 ohms. **Ruge-De Forest Inc.**, 50 Moulton St., Cambridge 38, Mass.

Circle No. **32** *on Reply Card*

Over-Running Coupling

Designed to accommodate all types of misalignment, new over-running mechanism is combined with a floating shaft flexible member which will compensate for both parallel and angular alignment errors without imposing excessive

load on the bearings in the clutch. Coupling is designed for boiler fan drives where the heat of the hot gases handled may cause expansion and misalignment. It can also be used on installations where the supporting members may be sub-



Speed Up Parts Loading with

FEEDALL

ELEVATING HOPPER FEED No. 2200

Low Loading and High Discharge Point

The magazine of this Unit has 4 cu. ft. capacity with 36″ loading height. Cleats on the conveyor belt pick up parts from the magazine and elevate them to the delivery point. Powered by a ¼ H.P. 3-phase Motor the Unit can be furnished to handle rolling cylindrical parts up to 3″ in diameter and 3/16″ to 1″ in length and long cylinders 3/16″ to 1″ in diameter and 3″ in length.

The Unit can be made for either right or left hand delivery or both.

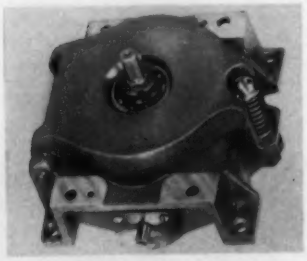
This is just one of many types of Automatic Feeders which we manufacture.

Why not let our engineers help you with your feeder problems. Write today.

FEEDALL
INCORPORATED
WILLOUGHBY, OHIO, U. S. A.

ject to deflection which would affect the shaft alignment. Floating shaft assembly can be lifted out of the drive to allow for inspection, maintenance and repair. **The Hilliard Corp.**, 100 W. Fourth St., Elmira, N. Y.

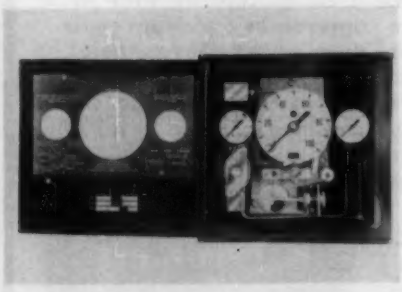
Circle No. **33** *on Reply Card*



Ball and Disk Integrator

Designed for use in computers and gunfire control systems in the solution of differential equations, ball and disk integrator is well adapted for use in high performance closed loop servo systems and is an accurate variable speed drive. Total ball carriage travel is 2 inches. Ball carriage is positioned by an angular shaft displacement. Ball bearings are used throughout. Integrator error in per cent of total local value is less than 0.001 per cent over most of the ball carriage range under typical disk speed and output torque conditions. Maximum dimensions are 1¼ inches by 1¼ inches by 3¾ inches. **Instrument Components Inc., Div., Belock Instrument Corp.**, 14-34 112th St., College Point, N. Y.

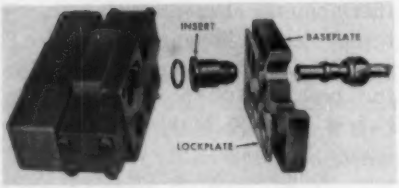
Circle No. **34** *on Reply Card*



Pressure Pilot

New development in pressure pilots features a self-contained, controlled-pressure gage. Pilot provides a range of control operations in a single unit. Changing from proportional to differential gap control, or from direct to reverse action involves shifting the turret type nozzle from one preset position to another. Both the proportional band and differential gap are adjustable from 1 to 100 per cent by turning a calibrated dial. Features of the new pressure pilot include an all metal relay, pneumatic feedback synchronization, full dampening controls for surge pressures and a sapphire feed orifice with a pushbutton cleaner. Pilot is available either separately, or mounted on diaphragm control valves in control pressure ranges from 15 to 5000 psi. **Kieley & Mueller Inc.**, 192 Genung St., Middletown, N. Y.

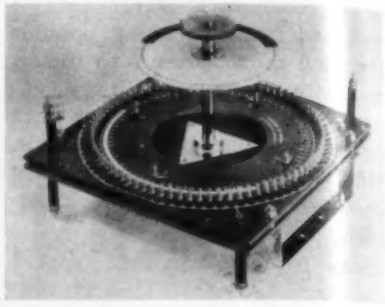
Circle No. **35** *on Reply Card*



Threadless Subplate

Threadless subplate for gasket mounted hydraulic valves eliminates pipe threads in body of valve and in subplate. Hydraulic valves for gasket mounting have fluid ports in one face of the valve body. This face is flat so that it can be bolted against the subplate having registered fluid ports. An O-ring seal at each port between the valve body and the subplate seals the hydraulic fluid against leakage. Subplate consists of three elements: inserts, lockplate and baseplate. Insert is the only part in the assembly subject to direct hydraulic pressure. It combines in one part the sealing face for the O-ring, the fluid passage through the subplate and the tube fitting connector body. The possibility of leaks due to the porosity of the baseplate is thereby eliminated. Lockplate is the metal plate that locks the inserts against rotation. It also provides the valve mounting surface flush with the gasket sealing faces on the inserts. Baseplates are made from cast gray iron and act both as the valve mounting pad and the bracket to hold and position the inserts. Subplates are available for individual mounting or multiple valve mounting. **Petch Mfg. Co.**, 461 York, Detroit 2, Mich.

Circle No. **36** *on Reply Card*



Electrical Switches

Among models available in line of electrical switches for special applications is an 81-position, two-circuit model of continuous rotation. Life span of the unit is over 50,000 operations. Individually spring loaded contacts are silver plated for low contact resistance. Rotor is of the printed circuit type with silver plating over the copper for low contact resistance and long wear. Voltage breakdown is approximately 1500v dc. A printed guard circuit eliminates leakage between contacts. Insulation resistance between contacts and between contacts and rotor is in excess of 25,000 megohm. Other models in line include rotary, self-cleaning, multiposition switches such as used in decade assemblies. **Industrial Instruments Inc.**, Cedar Grove, N. J.

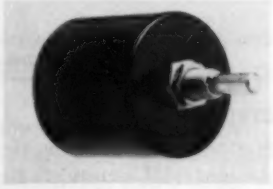
Circle No. **37** *on Reply Card*

Flow Control Valve

Two stage, four way valve controls hydraulic flow proportionally to an input current signal. Its pilot stage is a hydraulic amplifier of the nozzle type driven by a torque motor employing the polarized relay principle. A miniature, high

force positional feedback loop between the torque motor and the main spool position encloses the nozzle stage. Torque motor is supplied in ranges of 200 to 3000 ohms dc resistance per coil. Signal levels as low as 6 ma differential current produce full valve flow when using the 3000 ohm coils. Supply pressures of from 500 to 3000 psi may be used. Principal application of flow control valve is in servo loops where high dynamic performance at high force levels is required. Valve operates satisfactorily in ambients of 250 F. **Cadillac Gage Co.**, 20316 Hoover Rd., Detroit 5, Mich.

Circle No. **38** *on Reply Card*



High Resolution Potentiometers

Device offers the equivalent of a 10-turn potentiometer although any setting can be made within less than two revolutions of the single control shaft. New assembly, called Esipot, consists of a high resolution single turn potentiometer which actuates a ten-position attenuator switch as the single turn potentiometer reaches the end of its travel in either direction. This switch transfers the single turn potentiometer to any one of the ten voltage positions provided on a ten-step attenuator switch. Because Esipot uses precision fixed resistors in the initial attenuator section, a wide range of resistance values are available. Assembly can be used to replace a pair of controls where both coarse and fine adjustment steps are desired. High resolution of unit makes it well suited for a zero adjust control or a precision gain control. Esipot assembly is 1¾-inch diameter by 1¾ inch long behind the panel, and mounts in a single 7/16-inch panel hole. Standard ¼-inch diameter operating shaft is provided. **Electro-Measurements Inc.**, 4312 S.E. Stark St., Portland 15, Oreg.

Circle No. **39** *on Reply Card*

NEW, INEXPENSIVE, HIGHLY EFFICIENT

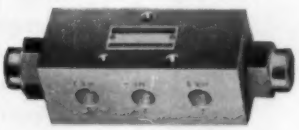
"O" TYPE" Quick-As-Wink® VALVES

NOW AVAILABLE

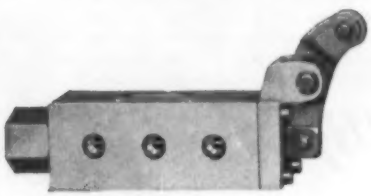
BUTTON OPERATED
(Push-Pull or Push Spring Return)

DIAPHRAGM OPERATED

FOR A WIDE

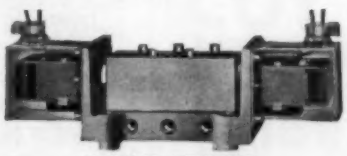


PILOT CYLINDER OPERATED
(Single or Double Pilot)

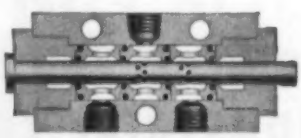


CAM OPERATED

VARIETY OF SERVICES



SOLENOID OPERATED
(Single or Double Solenoid)



CUT-AWAY VIEW OF INTERIOR
U. S. Pat. No. 2,645,450

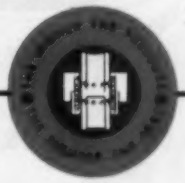
● These newly developed valves combine greatly simplified construction, positive positioning of all parts and quick, easy repacking in the field. There is no direct impingement of flow across the packings, greatly prolonging their life. All metal parts are aluminum except the hollow, radially ported, stainless steel plunger. ⅛" and ¼" pipe connections. 2, 3, 4 and 5-way actions. Write for Bulletin No. 531 today! *It gives full details.*

Ask us also about . . .

SINGLE PLUNGER SOLENOID VALVES in single or double solenoid designs. Low amperage requirement eliminates intermediate relays and simplifies electrical control circuits.

WATER SYSTEM VALVES pilot cylinder operated, sizes to 8". Can be installed with automatic remote control as a plant protection measure to shut off water to certain parts of the plant in case of emergency so the entire available supply is directed where it is most needed.

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves



Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 2074 East Pershing St., Salem, Ohio

How to **STAKE** and **BEND WITH YOUR THUMB!**

NEW! Clippard 3-Way Miniature Air Valve MAV-3

One of the hundreds of time and work saving uses for the *new* CLIPPARD Miniature 3-Way Normally Closed Air Valve is shown above. Jig is constructed so that a force of 75 lbs. is exerted on work by a 1" air cylinder (operating at 100 psi) when manual push-button is pressed. Stem travel of new MAV-3 Valve is 1/16" with overtravel of 1/32". Valve will handle up to 150 psi. Roller Cam-follower Head and a complete line of miniature Air Cylinders, Manifolds, Fittings and Accessories also available for that new automatic, or semi-automatic project you are now developing. Write, today, for details, catalogue sheet and prices.

Clippard INSTRUMENT LABORATORY, INC.
7350 Colerain Road, Cincinnati 24, Ohio

Manufacturers of R. F. Coils, Electronic Equipment, Miniature Pneumatic Devices

LIQUID LEVEL *and* **INDUSTRIAL CONTROLS**

Positive! Dependable! Economical! No floats! No moving parts in liquid. Unaffected by acids, caustics, pressures or temperatures.

Induction relays, magnetic contactors and starters. Special control panels.

WRITE FOR COMPLETE CATALOG

B/W CONTROLLER CORPORATION
2190 E. MAPLE ROAD BIRMINGHAM, MICH

FIRST IN THE FLOATLESS CONTROL FIELD

AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Components

TWINE AND WIRE ELECTRIC STOP SIGNAL

Electric switch device responsive to breaking or slackening of a flexible material extended through the switch. Patent 2,702,326 by Bernard D. Bodmer.

MINIATURE PRINTED CIRCUIT ELECTROSTATIC GENERATOR

Rotatable and stationary elements of this electrostatic generator consist of a polystyrene disc and plate on which conducting carriers have been printed. Patent 2,702,353 by Jacob L. Herson, Saul R. Gifford and Sachio Saito, assigned to the United States of America.

• • •

Data Processing

MECHANISM FOR STAMPING AND FEEDING A PAPER TAPE

Means for making an impression on a tape and means for feeding the tape between successive impressions. Patent 2,701,522 by Harold E. Hobby, assigned to Simplex Time Recorder Co.

• • •

Handling

ARTICLE HANDLING APPARATUS

Uses an intermediate storage conveyor to automatically receive articles from a supply conveyor and transfer them to the carrier hooks of another conveyor. Includes means to prevent discharge to the receiving conveyor when the carrier hook on that conveyor is full. Patent 2,700,448 by William L. Ames, assigned to Western Electric Co. Inc.

DISCHARGE DEVICE FOR ARTICLE WEIGHING AND SORTING MACHINES

Individual scale units on conveyor assume relative vertical positions according to the weights of

the cans being carried. Shields on the scale units interrupt a light beam directed toward a photoelectric cell in response to weight variation. Electromagnets actuated by the photoelectric cell remove offweight cans from line. Patent 2,702,120 by Ronald E. J. Nordquist, assigned to American Can Co.

• • •

Machines

MACHINE FOR GRINDING CONICAL SURFACES

Conical surface is ground on workpiece supported by a cylindrical section of the workpiece. The workpiece is rotated and urged axially to a stop by action of a driving belt running over the piece in a helical path. Patent 2,701,429 by Leslie Hartridge.

• • •

Measuring

APPARATUS FOR MEASURING LIQUID LEVEL

Plurality of thermocouple pairs are located in uniformly spaced vertical alignment from bottom to top of liquid container. Liquid level is indicated from amount of direct current generated by the thermocouple pairs when simultaneously heated by alternating current. Patent 2,702,476 by Deslonde R. de Boisblanc, assigned to Phillips Petroleum Co.

TABLET COUNTER

Articles fed from holder or hopper are aligned and a movable platform transfers a predetermined quantity from the line to a receiving spout. Patent 2,701,671 by Eino E. Lakso and Eugene E. Lakso, assigned to the Lakso Co. Inc.

APPARATUS FOR MEASURING THE THICKNESS OF NON-MAGNETIC COATINGS ON MAGNETIC MATERIAL

A potential is obtained related to the thickness of coating applied to a strip in a continuous coating process. Four coils in magnetic heads located two before and two after the coating process are connected in a bridge circuit. Patent 2,703,384 by George H. Rendel, assigned to U. S. Steel Corp.

• • •

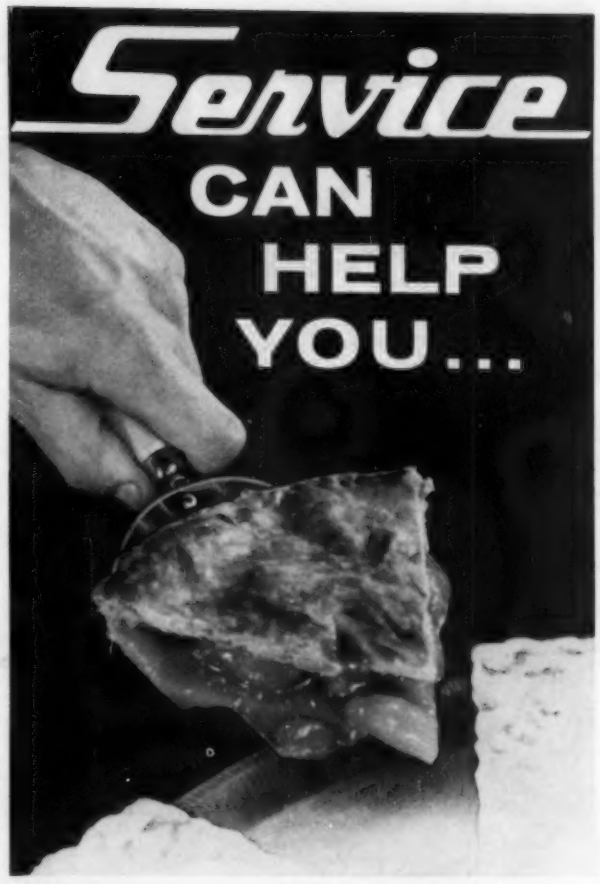
Packaging

BAG TOP SEALING MACHINE

Heated nozzle adjacent a continuously moving carrier of workpieces intermittently extrudes a molten thermoplastic coating material against the individual workpieces which are made to actuate the means that operates the extruder. Patent 2,700,260 by Hans C. Paulsen, assigned to B. B. Chemical Co.

APPARATUS FOR HANDLING ARTICLES TO BE NESTED

Device lifts an article from a conveying platform, turns it upwardly 90 degrees and nests it into the vertical filling opening of a receptacle. Patent 2,701,651 by Alfred E. Comstock, assigned to General Package Corp.



CUT A BIG SLICE
Out of Your Operating Costs!

Handling costs average 30% of total manufacturing cost in most industries today! To meet current competitive conditions, manufacturers are analyzing their handling operations to cut costs wherever possible. Almost without exception, the answer to the problem is found through the use of automated production handling equipment.

Service Conveyor Company can help you determine how you can cut handling costs in your operation, and *how far* it is practical and profitable to go! Drawing upon our twenty-five years of experience in the field of practical automation, we can engineer, manufacture and install automated facilities that will meet your specific requirements.

Service-engineered automation does not mean installing all new equipment. We utilize your existing facilities, supplementing them with the additional equipment required for automated production flow. At your request, a Service engineer will gladly visit your plant, and discuss your production problems. There's no obligation. Write or phone today.

SERVICE CONVEYOR CO.
7764 BRYDEN AVENUE, DEPT. 17
DETROIT 10, MICHIGAN

Engineered Automation—Ideas, Methods and Experience

new CATALOGS AND LITERATURE

Precision Tool Grinding Equipment

Oliver Instrument Co.—Eight-page brochure discusses tool and cutter, template tool bit and face mill grinders, drill pointers, drill point thinners and die making machines. Photographs illustrate machines in various applications. Specifications of models are also included.

Circle No. 50 on Reply Card

Machine Catalog

Emhart Mfg. Co.—More than 275 different types of machinery are described in 40-page illustrated catalog. Booklet is a condensed catalog of machinery produced by four company divisions which make automatic dieing machines, precision power presses and feeds, glass container making machinery and automatic packaging equipment. Dieing machines ranging in size from 25 to 400 tons are illustrated and described in detail. Specifications and illustrations of precision power presses and feeds complete the metalworking section. Among packaging machines covered are gluers and sealers, bottle and can packers, automatic milk casers, labelers, dumpers and unscramblers, case printers and stampers.

Circle No. 51 on Reply Card

Conveyor Catalog

Standard Conveyor Co.—Gravity and power conveyor and dispatching systems are discussed in a 26 page, illustrated catalog. Industries are divided into four categories in the catalog: metal working, chemical, food and beverage plants, and miscellaneous. Separate divisions under each general field are covered, with applicable types of conveyor equipment illustrated. Among conveyors covered are roller, spiral chute, belt, vertical lifts, roller spiral and push bars. Catalog contains numerous application photographs.

Circle No. 52 on Reply Card

Pneumatic Control Handbook

Industrial Div., Minneapolis-Honeywell Regulator Co.—Comprehensive 46-page bulletin describes pneumatic control and transmission systems. Separate sections are devoted to types of pneumatic controllers and their applications, transmission of pneumatic signals, cascade and ratio control in pneumatic systems, time element in pneumatic systems, interconnected control systems, manual adjustment for automatic controls, and providing an adequate source of clean air supply. Numerous sketches are used to illustrate each section, and a subject index provides a convenient reference for the readers.

Circle No. 53 on Reply Card

Tape Operated and Control Equipment

Commercial Controls Corp.—General brochure discusses how Flexowriters integrate data processing. Individual brochures illustrate Model FC which punches communications tape as a byproduct of typing in page form, FG which prepares tape to emboss Addressograph plates, FTM which provides an interoffice teletypewriting system, FPC which uses a program tape in form preparation, and FL which types repetitive copy automatically. Additional sheets discuss the Justowriters which set justified copy automatically, tape converters and tape verifiers. Numerous photographs, and specification and application data are included.

Circle No. 54 on Reply Card

Time Delay Unit

Automatic Control Co.—Data sheet discusses time delay unit, called the Motorelay Siamese Timer. Unit is designed for industrial and municipal installations to provide automatic timing delays. It may be used in industrial machines, chemical processing, water distribution and sewage treatment. Single motor drive in timer drives two timing cycles independently so that start and stop cycles operate separately. Data sheet includes photographs of Siamese timer and the timing assembly.

Circle No. 55 on Reply Card

Marking Machines

Adolph Gottscho Inc.—Four-page bulletin describes automatic production line units for identification marking and code dating of packages and products. Attachments illustrated, for installation on other equipment, print continuous designs or repeated copy legends on small cartons, continuous webs of flexible materials, front and side panels of cases, rear and side panels, etc. In-line machines are shown for imprinting code dates, colors, sizes, flavors, contents descriptions, etc. Additional photographs of automatic bulk fed and semiautomatic marking machines complete the bulletin.

Circle No. 56 on Reply Card

Electric Proportioning Control

Leeds & Northrup Co.—Fourteen-page brochure describes electrical proportioning control systems for variables such as temperature, pH, electrolytic conductivity and gas concentrations. Position adjusting type control is available in package containing recorder, control unit, drive unit, and primary element such as thermocouple, pH electrode, conductivity cell and gas analyzer. Duration adjusting and proportional action controls are also discussed, with circuitry of three control types included. Photographs of various models and circuitry diagrams are included in the brochure.

Circle No. 57 on Reply Card

Circuit Controlling Counter

Counter and Control Corp.—Eight-page brochure discusses multistage circuit controlling counter with automatic recycling. Designated the Programonitor, unit will count shaft revolutions at speeds up to 4000 rpm, select any count cycle setting up to 2000 counts, arrange intermediate switching points in any progressive sequence, and recycle the switching pattern on a fully automatic basis. Types of program cylinders and chassis models are illustrated. Specifications and data on switching patterns and adjustment of Programonitor are given.

Circle No. 58 on Reply Card

Broach Catalog

American Broach & Machine Co., Div., Sundstrand Machine Tool Co. — Thirty-two page catalog discusses line of broaches and broaching machines and their applications. Separate sections are devoted to internal broaches, surface broaches and broach pullers. Keyway broaching, resharpening and care of broaches is also covered. Internal and surface broaching operations are discussed. Among photographs of surface broaching machines is illustration of automatic loading and continuous broaching cycle machine. Numerous application photographs are included in the catalog, along with pictures of typical broached parts and diagrams illustrating broach design.

Circle No. 59 on Reply Card

Solid Shaft Motors

U. S. Electrical Motors Inc.—New brochure illustrates line of vertical solid shaft motors. Cross sectional views portray details of design and special features are presented in enlarged illustrations. Among features of motors shown in bulletin are asbestos protected windings, normalized castings, deeply recessed air openings for protection against weather, transverse lubrication, and electronically balanced rotor. Brochure also describes footless type horizontal motors for direct connection.

Circle No. 60 on Reply Card

Hardening Machines

Cincinnati Milling Machine Co.—Method of hardening, brazing and heat processing by precision selective heating with electronic control is discussed in a 22-page publication. Different models of hardening machines are photographically illustrated, and brief descriptions of their applications are included. Specific applications are shown for chuck scrolls, cams, hook rollers, drive gears, ring gears, camshafts, crankshafts, lathe bedways, propeller bearings, rocker arms and transmission shafts. Bulletin contains diagrams of standard hardening machine, its control cabinet, the power control unit, and a list of other company manufactured machines.

Circle No. 61 on Reply Card

DC Amplifier

Hagan Corp.—Ten-page bulletin describes features and specifications for a new dc amplifier. Unit can be used with such elements as thermocouples, radiation pyrometers, thermal converters and dc strain gages in control systems, telemetering, stress and temperature measurements, and other applications where low voltage dc amplification is required. Graphic pictorial diagrams and descriptive matter are contained in the bulletin, as well as selecting and ordering information.

Circle No. 62 on Reply Card

Automatic Equipment

Continental Industrial Engineers Inc.—Sixteen-page brochure discusses engineering facilities and services of Continental. Photographs illustrate complete plants, production lines and special automatic machines designed by Continental. Also shown are furnaces, ovens, kilns and atmosphere generators available from the company. Processes such as metal coating, hardening, drawing, heat treatment of brass and aluminum, bright and clean annealing, brazing, gas carburizing and salt bath treatment are discussed, with photographs illustrating actual applications.

Circle No. 63 on Reply Card

Shut Off Valves

Eclipse Fuel Engineering Co. — Four-page brochure describes features of safety shut off valves. Among these are an increased range of sizes, now from 1 to 6 inches, and new electrical power control unit which gives an increase in effective piston pressure. Valves are designed for all types of gas

combustion systems. Brochure includes photographs of valves, operating and construction details, application information and dimension tables.

Circle No. 64 on Reply Card

Mass Spectrometer

Consolidated Engineering Corp.—Mass spectrometers designed for use in fields of industrial development, laboratory analysis and research are discussed in 16-page illustrated brochure. Operating information and applications of spectrometers in control and exploratory analyses, purity determinations, research investigations and complex mixture analyses are given. Components discussed include: sample introduction system, analyzer assembly, vacuum systems, magnet, ion-accelerating voltage supply, mass marker, protective circuits, voltage control, recording system and temperature control. Separate sections are devoted to features, analysis procedure, service, accessories and ordering information.

Circle No. 65 on Reply Card

Conveyor Catalog

Conveyor Systems Inc.—Trolley, roller, slat, chain, belt and special model conveyors are discussed in 64-page catalog. Photographs of conveyors in actual applications are shown. System and component specifications and design data are included. Special models illustrated include barrel handling conveyors, pin and spindle type conveyors, bulk conveyors, and incline conveyors. Attachments for different models are covered.

Circle No. 66 on Reply Card

Automatic Lubrication

Trabon Engineering Corp. — Four-page folder outlines automatic lubrication systems for use on machine tools. Systems which meter lubricant, oil or grease in accordance with machine and production requirements are illustrated in actual applications. Photographs of various models and their specifications are included.

Circle No. 67 on Reply Card

Electric Chain Hoist

Chisholm - Moore Hoist Div., Columbus McKinnon Chain Corp.—Twelve-page bulletin describes electric chain hoists up to 2000-lb capacity. Among features of electric hoists shown are fully enclosed housings, interchangeable suspensions, self-adjusting brakes, shock proof pushbutton controls and lifetime lubrication. Bulletin includes photographs, specifications, and diagrams of various models. Accessories such as tandem trolley and chain container are also illustrated and discussed.

Circle No. 68 on Reply Card

Rubber Covered Hose and Fittings

Parker Appliance Co.—Four data sheets describe rubber covered single fiber braid (nonmetallic) hose designed for low pressure service. Also covered are reusable brass fittings for this hose. Hose is used with hydraulic fluids, water, crude and fuel oils, hot oil, diesel fuels, gasoline and air. Fittings illustrated include swivel nut, male pipe thread, and flare end models. Specifications, applications and photographs of hose and fittings are given.

Circle No. 69 on Reply Card

Moisture Controllers

Fielden Instrument Div., Robertshaw-Fulton Controls Co.—Four-page brochure discusses moisture controllers for use on dryers, tenters or slashers. Instrument is used to detect the moisture content in warps or fabrics of any fiber or fiber mixture. Brochure covers applications and description of controllers, and a block diagram of an automatic moisture control system.

Circle No. 70 on Reply Card

Subminiature Precision Switches

Micro-Switch Div., Minneapolis - Honeywell Regulator Co. — Literature on environment proof subminiature precision switches includes a preliminary data sheet and a four-page brochure, "Micro Tips". Data sheet gives

HARTFORD *Special* DRILL UNITS* have POWER PACKED FLEXIBILITY

ADJUSTABLE RATE OF FORWARD FEED
ADJUSTABLE DISTANCE OF RAPID APPROACH
BACK FEED SELECTOR
ADJUSTABLE FINAL DEPTH— Micrometer control to within .0005"
plus ADJUSTABLE SPINDLE SPEEDS— Pulley, direct, gear and variable speed drives
plus OPERATION IN ANY POSITION

3 MODELS FROM ⅓ to 5 H.P. TO GIVE COST SAVING PERFORMANCE ON THESE OPERATIONS

Drill—Single and Multiple Spindle	Ream	Countersink	Bore
Deep Hole Drill	Spot Face	Outside Thread	Mill
Tap	Center	Hollow Mill	Face
	Chamfer	Counterbore	Recess

*Formerly produced under the trademark "Delta-Milwaukee" by the Rockwell Mfg. Company

Backed by the proven performance of thousands of units in hundreds of plants, the job flexibility and positive control of "Hartford Special" Drill Units make them a prime mover for any tool. Combined with "Hartford Special's" standardized machine components, they offer every manufacturer, regardless of size, the benefits of automatic production and the ability to switch from job to job at the lowest possible cost . . . Write for new catalog.

HARTFORD *Special*

MACHINE TOOL DIVISION
THE HARTFORD SPECIAL MACHINERY CO. F-502-7
285 Homestead Avenue, Hartford 12, Conn.

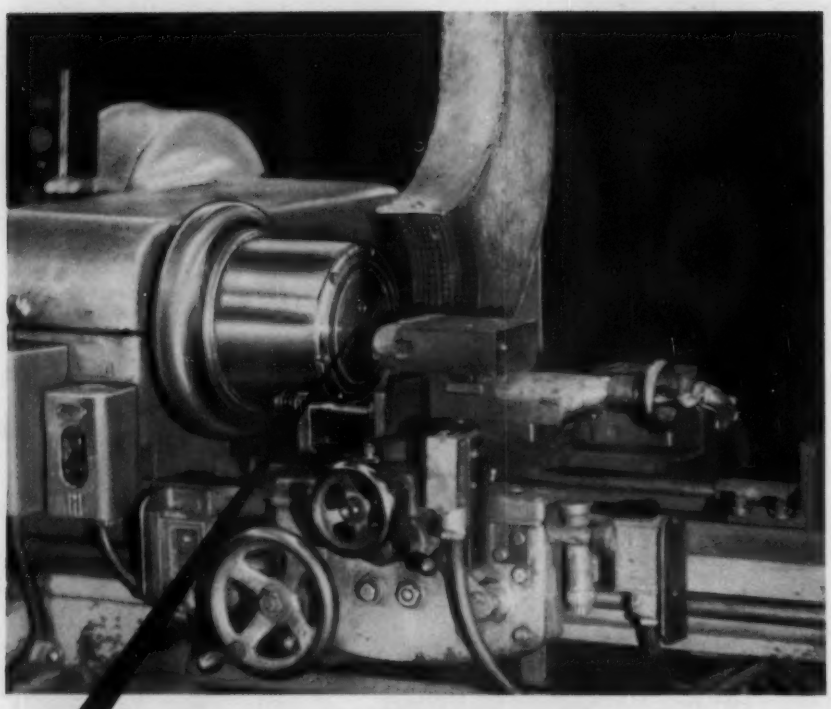
☐ Please send me new Drill Unit catalog, with application Data Sheet.
☐ Please have Field Engineer call.

Name_____

Company_____

Address_____

City_____ Zone____ State_____



Magna-Lock Magnetic Chuck

at Wabash Division, Raybestos-Manhattan, Inc.

SOLVES PROBLEM OF HOLDING THIN WORK-PIECE

THE JOB: Machining spiral groove .030" wide, .015" deep with 1/16" space between grooves on steel plate faced with copper friction material.

THE PROBLEM: To hold 1/16" thick copper-faced steel plate firmly on a lathe during the grooving operation.

THE SOLUTION: A Hanchett MAGNA-LOCK Rotary Magnetic CHUCK holds work piece which is machined at a spindle speed of 600 RPM.

THE RESULT: 2,400 pieces machined per 8-hour shift. Scrap and rejects run less than 2%.

Here you have another example of how Hanchett Magna-Lock Magnetic Chucks can increase your machine's productivity.

Magna-Lock offers a complete line of rotary, rectangular, swiveling and vertical face magnetic chucks, magnetic sine chucks, parallels and accessories. Magna-Lock Rectangular Chucks have 22% more magnetic area, permitting work pieces to be held to the extreme edges of the chuck. They are of welded *all-steel* construction, shock-proof and moisture-proof.

Get Magna-Lock for extra holding power that holds an extra margin of profit for you! WRITE TODAY, Dept. A-75.

Request Magna-Lock as original equipment on your new machines.

Hanchett MAGNA-LOCK CORPORATION

Magnetic Chucks and Devices

BIG RAPIDS, MICHIGAN, U. S. A.

NEW CATALOGS

operating characteristics, specifications, and photographs of manually operated switch components—slide button switch, push button assembly, sealed toggle switch, toggle switch assembly, push button assembly and rotary selector switch. "Micro Tips" illustrates different applications for switches.

Circle No. 71 on Reply Card

Live Rail Conveyors

Alvey-Ferguson Co.—Four-page bulletin describes controlled storage for boxed components with a "rolling floor" made of live rail conveyors. Level conveyor lanes give first-in, first-out system and are adapted for palletized loads and fork truck operation. Photographs of applications are used to illustrate the brochure.

Circle No. 72 on Reply Card

Net Weighing Machine

Exact Weight Scale Co.—Four-page bulletin describes fully automatic net weighing machine for packaging, bagging, batching, and compounding. Machine is used to feed chemicals, plastics, food products, tobacco, seeds and powdered metals. Photograph of machine and two specification charts are included. One chart outlines specifications of net weighers; the other describes semiautomatic weighing machines.

Circle No. 73 on Reply Card

Control Valves

Mason-Neilan Regulator Co.—Comprehensive 72-page catalog discusses line of control valves and auxiliary equipment. Catalog is divided into five sections: construction, in which diaphragm motors, valve bodies and trim, materials and packing are discussed; standard control valves, in which eight types and various models of each type are covered; special control valves, in which six types are covered; auxiliary equipment, in which handwheels, positioners, volume boosters, loading valves, reversing relays, limit stops, etc., are discussed; and an appendix giving technical data on flow characteristics, rangeability, valve sizing, pressure drop limitations, etc. are described. Catalog includes photographs of equipment discussed, and has numerous diagrams, and charts.

Circle No. 74 on Reply Card

Hydraulic Standards Bulletin

Miller Fluid Power Co.—Revised issue of the J.I.C. hydraulic standards for industrial equipment presents the standards in complete, unabridged form including all revisions made at the January 1953 meetings of the Joint Industry Conference. Also included in 20-page bulletin are recommended practices for hydraulic packings and seals, examples of packing code identification, sample circuit using J.I.C. symbols, and glossary of terms.

Circle No. 75 on Reply Card

Load Cells and Load Beams

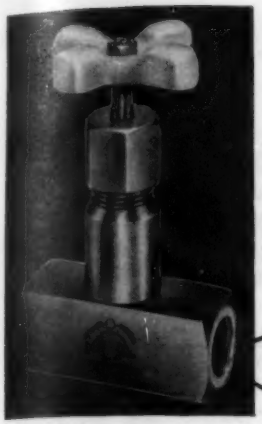
Baldwin-Lima-Hamilton Corp.—Features of load cells and load beams for measurement of weights and forces are presented in a 20-page bulletin. Sketches and photographs illustrate construction and applications of the units. Photographs also show instruments for use with load cells and load beams. Dimensional drawings, specifications and engineering recommendations are included.

Circle No. 76 on Reply Card

Electronic Control System

Swartwout Co.—Four-page brochure describes components for electronic control systems for process and power instrumentation. Illustrated are the controller, recorder, indicator, power relay, temperature transmitter, thermocouple-air converter, pressure transmitter, flush diaphragm pressure transmitter, differential pressure transmitter and adapter units, which are available. Photograph and brief description of the function and working principles of each unit are given.

Circle No. 77 on Reply Card

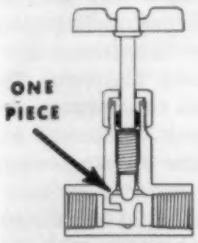


New MARSH Needle Valves

MAXIMUM WORKING PRESSURE 10,000 PSI

. . . for finer regulation of water, oil or gas

First needle valve to combine all the characteristics called for in modern industry. Embodies sturdiest basic construction—machined from solid bar stock—suitable for pressures to 10,000 psi and equally efficient in lower range. Note stem guide fused to body by new "Conoweld" process, eliminating faults of conventional two-piece valves. Stem 416 stainless steel. Stem threads fine pitch for strength and micrometer regulation. Body electro-zinc plated. Sizes ⅛" to 1", globe and angle patterns.

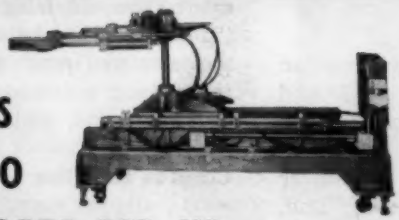


Ask for new Needle Valve Catalog

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp* Dept. X, Skokie, Ill.
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd Street, Edmonton, Alberta, Canada

---

HAMILTON PRESS HELPER PAT. APP.



PULLS UP TO 900 PARTS PER HR. AUTOMATICALLY FROM PRESSES

PORTABLE, NOT ATTACHED TO THE PRESS—IDEAL FOR THE JOB SHOP—FOR SAFETY IT TAKES THE HELPER FROM THE BACK OF THE PRESS

A STANDARD METHOD OF PULLING DOORS, HOODS, ROOFS, PANS, ETC.

Hamilton *Inc.*

Automation

1490 EDISON AVE. (25) HAMILTON, OHIO

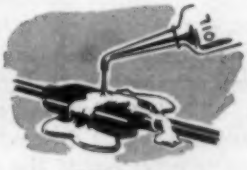
Partners in Production

Joy Electrical Connectors and Automatic Controls

What happens to Automation . . . when electrical connectors fail?

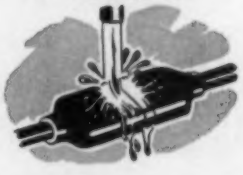
No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out.* That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Co. (Canada) Limited, Galt, Ontario.*

Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.



Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.

Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.



Free . . .
New Bulletin — Ask for No. B59

CD 355.2

JOY

SOURCE OF INDUSTRY'S FAVORITE ELECTRICAL CONNECTORS SINCE '28

AUTOMATION abstracts

MOVEMENT IN AUTOMATION

R. C. WAEHNER
Lever Brothers Co.
New York, N. Y.

AUTOMATION has removed the drudgery from everyday manual labor, and utilized the abilities of the American worker to effectively use mechanized equipment. In recent years, this has been particularly true in the field of movement. By movement, I refer to the physical handling of raw material from the original supplier to the processor, and the subsequent handling of finished goods from production through warehousing and shipping; transfer between cities to public warehousemen; within public warehouses; and, finally, to the ultimate customer.

Lest we think that we have invented and conceived a further improvement in American industry, it is best that we realize the practice of automation has existed for years in varying degrees. Only the term is new; but if the use of the new word serves to arouse the curiosity of industrial management, it is an invaluable addition to our vocabulary. In the past three decades, management has concentrated on the improvement of sales and production efficiency, and developed both to a high art; but little attention has been paid to what is commonly called receiving, warehousing, shipping, traffic, or distribution—all of which can be embraced in the one term, movement.

The perfect climate for the practice of automation occurs where orders for finished products are placed in advance of production. For example, several of our national bakeries secure customer orders for delivery two or three weeks hence, and production begins on receipt of the order. Complete unitized flow exists from the supplier of the basic raws to the bakery, through his process, to the final consumer. The baker can schedule his raw materials to meet his order commitments, and take advantage of automation to the *n*th degree, by the use of material handling devices, *Fig.* 1, and specially-designed unitized loads provided by the supplier, to coincide with the baker's production requirements. Automation continues through production to the delivery units, and product is never touched by human hands.

Unit Loads

Material handling in automation is synonymous with speed and economy of operation. In our field, distributors and chain organizations are increasing stock turnover through automatic handling and, equally important, reducing dollar value of inventory levels. Axiomatically, this implies smaller but more frequent replenishment orders. Fundamentally, this trend favors the motor carriers, as trucks have a smaller cubical capacity, and provide lower minimum weights.

An example is the trend toward palletized delivery. At the present time, palletization ends at the tailgate of the truck, but in the future it is reasonable to conceive that the units of sale and discount may bear a direct relationship to the ideal, unitized load. This will require radical changes in motor carrier and rail equipment. The common carriers, both via highway and rail, must undertake engineering activities in collaboration with shippers to overcome the unfortunate fact that the bulk of trailers and railroad rolling stock effectively prevents automation beyond the shipping platform. The speed with which the common carriers provide such equipment will directly determine future tonnage levels.

In England today, the railroads are providing shippers with special box cars designed to handle palletized materials. When cars of such design progress beyond the drawing-board stage and become a reality, the common carriers of our country will recover tonnage that industry has diverted to contract and private carrier because of their ability to provide special equipment. The old adage still applies, "If you wish to be competitive tomorrow, you must be progressive today."

Costs in Handling

I can best cite the progress of automation and its effect on transportation by relating the experiences of our company in its quest to reduce expenses, to enable us to continue to deliver a high-quality product at competitive price levels to our customers. Not too many years ago, raw materials were purchased indiscriminately to take advantage of rising market prices, without consideration of the problems and expense in storing and ultimately delivering these raw materials to the production line, and specifically, with little consideration as to the overall effect of the subsequent handlings on the

cost of finished goods. Such situations frequently resulted in substantial demurrage charges, plus costly outside storage and handling, and subsequent transit charges, or if transit was not available, prohibitive trucking costs.

We have, in recent years, developed integration and communication with involved departments to a highly refined science of the relationship of needed component ingredients, not only to weekly, but daily production requirements, to enable the distribution division to intelligently move raw materials from the suppliers' point of business to our production lines. From the standpoint of transportation, this has required close collaboration by our traffic manager with transportation officials for the maintenance of rigorous schedules. By "rigorous schedules," I do not mean special, costly, "hot-shot" service, but consistency in elapsed time between suppliers' place of business and our production lines, as a delay of 24 hours could feasibly result in a shutdown of our plant facilities.

An example of such stop-watch scheduling exists between our company and our can suppliers. Cans are loaded loose in railroad cars, ready for use on the production line, and are efficiently moved by conveyor, direct to the production line. Prior to the inception of this method, it was necessary to store cans with subsequent rehandling, incurring high labor costs to manually feed production lines. In addition, rehandling caused substantial damage. Countless thousands of dollars were saved by close collaboration between supplier, transportation carrier and processor. Today this is standard procedure in canneries throughout the country.

We collaborate daily with our purchasing department and, through their efforts, have encouraged many suppliers to furnish our various packing materials and sundry raws in unitized loads, with each unitized load directly related to the unit of use at the particular point of the production line, giving full consideration to space limitations and hourly requirements of the production line, to avoid, in most instances, intermediate handling. This usually results in two considerations—the area available at point of use; or, if limited area and access are not a factor, we select the largest practical unit size, giving due consideration to worker fatigue in handling. For example, it is our opinion that a unitized load requiring an employee to reach above 6 feet or bend to within 18 inches of the floor will result in undue fatigue and overall reduction in efficiency.

It is therefore apparent that automation begins with the design of the production line—the providing of floor loads of sufficient capacity—columns of proper spacing—aisles of adequate width—and floor space requirements at point of use on production line to conform to the size of the unitized load of packing materials and sundry raws in direct ratio to their use, to enable the fullest possible use of mechanized equipment.

I would like to dwell for a moment on lines of communication, as integration of divisions within a company cannot exist without good communications. In this age of specialization, to deny communications to a specialist, a material handling engineer, a traffic manager, a production manager, effectively limits his productivity. A specialist in one division must integrate his activities with specialists in other divisions.

Automation in Warehousing

Our new Hammond Warehouse is a good example of carrying automation through to the eventual

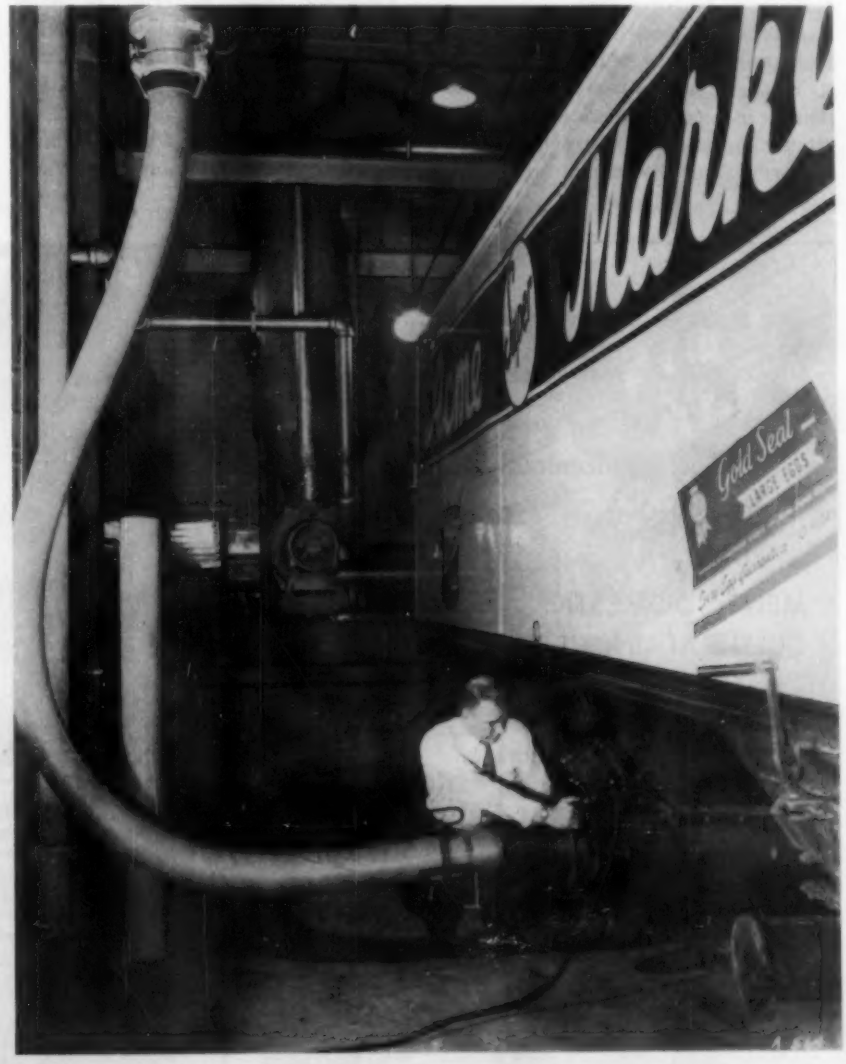


Fig. 1—Flour and sugar are normally received in bulk by special trucks or railway cars provided with special outlets. Flexible intake hoses can be attached quickly for unloading purposes

shipping platform. All goods move from the case sealer by means of two common conveyors, directly into the storage warehouse. Within the warehouse, electronic case selectors automatically divert each pack and brand to separate accumulator belts, *Fig.* 2, to await their turn for automatic palletization. The degree of efficiency achieved through this process is almost beyond belief. Even to the experienced material handling expert, it is intriguing to watch the almost human action of the automatic case selectors unerringly taking off any one of six different packs onto six different accumulator belts, and then to watch one palletizer automatically change its interlocking pattern to produce any one of the six different pallet patterns designed to efficiently utilize the cube of the pallet, with proper interlocking features.

After the loaded pallet is discharged from the palletizer, *Fig.* 3, it can either be removed at the point of palletization by fork trucks, or automatically moved to a lower floor by means of automatic Lowerators. A further innovation is the ability to discharge any particular item in production to a predetermined location close to its eventual point of storage, to minimize the distance to be traveled by fork trucks. This warehouse is a perfect example of the elimination of drudgery from warehousing; of providing the worker with mechanical equipment to increase his output, permitting management to continue to provide an ever-increasing standard of living.

Recent Advances

In the last year, and in fact in recent months, developments in unitized handling have occurred which portray an even brighter future. We are all aware of the back-breaking labor involved in handling bulk material in bags. There is now available to the alert user collapsible rubber drums which permit the unitized handling of as much as 12,000 pounds of powders or liquids, which, because of their design, enable the transfer of contents from container to storage bin in a matter of minutes, rather than hours. Most of us have seen a worker attempting to handle a load of carbon black. At the conclusion of his chore—in addition to physical fatigue—he presented the appearance of a miner emerging from the pit. This same employee can now handle carbon black, theoretically, in white tie and tails.

Our railroad car-leasing companies have aggressively approached the problem of automation and efficiency in handling. Covered hopper cars are now available which reduce unloading time 80 per cent in handling quantity receipts of powders. Can you visualize unloading 150,000 pounds of chemicals in less than two hours? Today, this is an accomplished fact.

Another example of automation is the new so-called "piggy-back service" of the railroads, providing prompt delivery of unitized loads of finished goods from point of production to ultimate consumer. In this system, pallet-loads of merchandise are loaded on trailer

STAMPINGS

Produced economically in our modern plant for:

AUTOMOTIVE, INDUSTRIAL EQUIPMENT, DOMESTIC APPLIANCE, AGRICULTURAL INDUSTRIES AND OTHERS; will boost your output at material savings.

Our production, engineering and toolroom facilities are geared to the volume usage of *your* industry.

Send us your inquiries

LANSING STAMPING COMPANY

1157 So. Pennsylvania
Lansing 2, Michigan
Serving Industry Since 1914

CUT OVEN COSTS 2 WAYS!

Grieve-Hendry STANDARD CABINET OVENS

1. LOWER FIRST COST
Through Size Standardization.

2. LOWER OPERATING COSTS
Through reduced heat losses.

Greater efficiency made possible by THESE FEATURES . . .

- 20% more insulation.
- No metal-to-metal contact.
- Selective heat intensity control.
- Constructed for heavier loads and faster processing.

Designed to include the latest convenience features and safety devices.

Specialists in precise temperatures and programmed processing. We offer you engineering consultation on your oven requirements. Call or write.

Standard models to 1000° F.

$89.50 and up

Immediate delivery

Dealers inquiries invited

GRIEVE-HENDRY COMPANY, INC.

1410 W. Carroll Ave., Chicago 7, Ill.

Export Dept. 306 W. Washington Blvd., Chicago 6, Ill.

trucks, hauled to the railroad yard for placement on flat cars, and removed at destination for a direct delivery to the customer, and unloaded by fork truck. In many instances, a unitized load may represent as much as 160 individual pieces. This represents a potential saving ratio of 160 to 1, multiplied by the number of times handled—into warehouse, out of warehouse, at the shipping dock, at the origin railroad terminal, at the destination railroad terminal, into delivery truck, and, finally, at the customer's facilities.

One of the latest innovations which is destined to change radically the marketing of everyday essentials used to feed, clothe and house our citizens, is the co-ordinated public distribution warehouse, which in one fell swoop serves not only the manufacturer, but the intermediate distributor, and finally, the shopkeeper supplying the public. The activation of these warehouses could completely outmode present distribution methods which require each manufacturer to deliver small quantities to many customers throughout metropolitan areas.

We are all familiar with the congestion in any of our large cities, brought about because of the many trucks making many deliveries to many stores. Under the proposed system of operation, each manufacturer supplying the various outlets in the community will maintain inventories of their products in this centralized distribution warehouse. The warehouse will send order blanks weekly to the distributors, the jobbers, and the chains who, in turn, will order their requirements as needed, based on the rate of disappearance of stock at shelf levels.

All manufacturers and transportation agencies have been aware of the prohibitive cost involved in making minimum deliveries—the tremendous amount of lost time and motion. From the viewpoint of the store owner, how much more efficient it would be to have one truck of 20,000 pounds deliver all the items needed, rather than 40 trucks averaging 500 pounds delivering for each manufacturer! It might be said that each competitive manufacturer would not want to lose his identity in effecting delivery to his customers. In actual practice, he loses his identity in the railroad merchandise car or the truck lines' merchandise truck. His merchandise is freely intermingled with that of other manufacturers who might be using the same carrier; and undoubtedly, on many occasions, his product is delivered with that of his competition on the same vehicle.

The centralized distribution warehouse, as planned, utilizes the philosophy of the individual merchandise cars from various origins to consumers in a given distribution area, and applies it on an area-wide basis. The goods of the various manufacturers in many towns come to rest at a central warehouse location, and are ordered as needed by the trade for delivery in one truckload. In addition to the economic benefit to the manufacturer, it permits the individual distributor to sharply reduce his investment in inventory.

We are only beginning to enter

Write today for your free copy of this Technical Paper.

ask for data file 712

Characteristics of Precision Servo Computer Potentiometers

BY D. C. DUNCAN

General Manager, Helipot Corporation

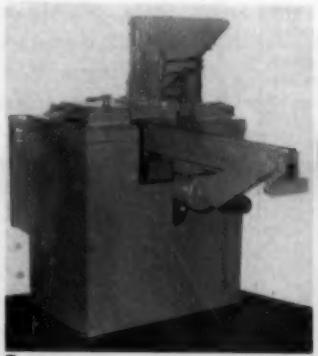
Presented at A.I.E.E. CONFERENCE ON FEEDBACK CONTROL SYSTEMS

388

Helipot *first in precision potentiometers*

Helipot Corporation / South Pasadena, California

a division of BECKMAN INSTRUMENTS, INC.



Another KDI Engineered Application

Shaft Hopper & Chain Feed Conveyor

Designed by practical minded KDI engineers for automatic operation, the combination shaft hopper and chain feed conveyor serve in unison to speed up and automate centerless grinding operations.

Both hopper and conveyor are mounted on rollers to compensate for grinder wheel wear. The conveyor is rigidly attached to the grinder at the other end. Both the hopper and conveyor are adjustable for a wide range of diameters and lengths. Unique alignment guides can be provided for tandem grinder set-ups.

Write for information on your parts handling problems.

kdi kraus design, inc.

964 EXCHANGE ST., ROCHESTER 8, NEW YORK

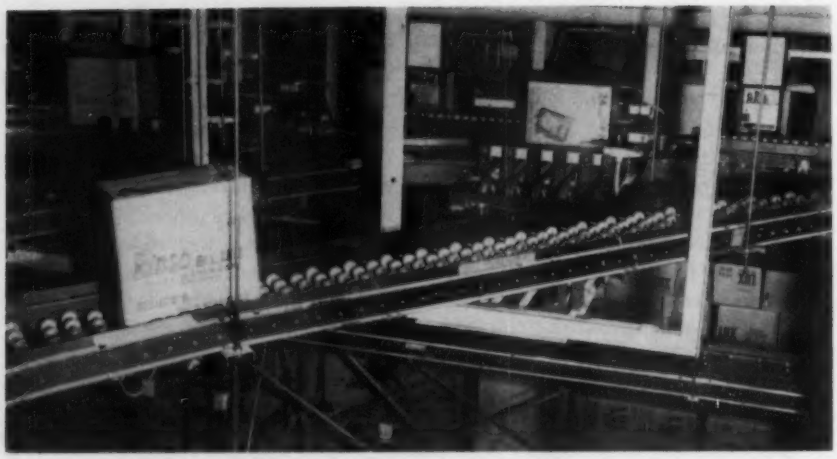


Fig. 2—View of the first two accumulating conveyors branching from the main conveyor. The automatic sorting and switching system has deflected the carton of Rinso detergent to the line in the foreground while, in the background, the set of five V-belts that provide the switching action is deflecting a carton of 24 Silver Dust onto the appropriate accumulator line

an era of automation in material handling which will enable industry, under our American free enterprise system to make more efficient use of manpower. The speed and degree to which this is accomplished rests with the industrial executives and the open-mindedness they give to the field of automation. No expense and effort has been spared to improve sales and production methods, but, to this point, relatively little thought has been given to distribution and the practice of automation. Unfortunately, engineering, as a general rule, ceases at the end of the production line.

From a talk entitled, "Automation—Its Potential and Effect on Movement and Transportation" delivered at the Centennial Celebration, Michigan State College, Lansing, Mich., April, 1955.

Fig. 3—On this short run of conveyor leading from the pallet loader, a loaded pallet may be picked up by a fork truck for storage on this floor, or may travel to a Lowerator that will take the pallet to the lower floor. When the truck passes the stripe on the floor, it interrupts a ligh beam, causing the conveyor to stop until the load is removed

MAGNETIC TAPES ARE VERSATILE

L. J. FISHER
Ree Co.
Santa Mon a, Calif.

MAGNETIC RECORDING is not a new art; Valdemar-Poulsen successfully used wire as a medium back in 1898. But until recent years it was mainly a curiosity. Development was slow because suitable materials were lacking, and the state of the art was not sufficiently advanced. It is even today, largely empirical in nature as theory is qualitative rather than quantitative due to complications introduced by ferro-magnetic materials.

Magnetic recording permits the permanent recording of signals without mechanically or chemically affecting the recording medium but merely changing its magnetic state. A record may be reproduced immediately without processing and does not noticeably deteriorate with reproduction or time. The tape may be easily stored or erased, and then reused. It allows editing of a record in order to pick out pertinent data and then play it directly into automatic data reduction equipment. Units are capable of simultaneous recording of many channels.

Time-scale changing is easily accomplished by recording at one tape speed and playing back at another. Thus, it can be used to speed up slowly varying data for convenience of observation or slow down the time scale of the data in order to be within the capabilities of oscillograph recorders.

Records can be played repetitively using an endless loop arrangement. This will allow a number of methods of detailed analysis such as frequency analysis, correlation of channels, and so on to be performed. Or a tape loop may be operated on continuously by erasing the old data and recording the new. Time delays or advance can be introduced by suitable positioning of the heads.

Data can be recorded on the spot, at a remote location, or telemetered from remote locations by wire or radio. Special installations can allow continuous monitoring, while at the same time, only special information is recorded. A recorder

can be set up to control or measure industrial processes.

Frequency and pulse modulation systems yield high accuracy and good frequency response for the recording of data. Furthermore, each system can be multiplexed in order to provide compact storage of many different channels.

Frequency Modulation

By converting the signal to be recorded into a frequency-modulated form, the intelligence is recorded on the tape as a variation in frequency. In order to recover the intelligence on playback, demodulation of the signal is performed by counting the rate at which the recorded signal crosses the zero axis.

The recording circuitry is simple, and since demodulation amounts to pulse counting, tape biasing and equalization are unnecessary. The playback signal is passed through several limiting stages in order to eliminate amplitude modulation prior to demodulation. The output signal is therefore independent of any amplitude variations of the voltage produced in the playback head. A low-pass filter whose cut-off frequency is lower than the lowest excursion of the carrier is an integral part of the demodulator. Its function is to permit only the average value of the pulse train to remain in the output signal. This average is the desired signal originally recorded.

By the use of frequency modulated carrier system, it is possible to record low-frequency information down to dc with negligible phase shift. Any phase shift which does occur in the system is due to the filter which is used to separate the carrier from the intelligence during demodulation. Clearly, it can be altered to meet particular requirements.

There are at present two principal disadvantages to a frequency modulation system:

1. Long - time stability when measuring dc
2. Noise produced by flutter and wow during recording, and subsequently, in playing back

Since the signal-to-noise ratio of the system is the ratio of the per cent deviation for maximum signal to the per cent flutter, it is apparent that a wide deviation is desirable. Therefore, deviations up to plus and minus 50 per cent of carrier frequency are used in most systems of this type.

In general, the circuitry is simple and reliable and compensation methods are available for correcting errors caused by flutter and wow. For instance, a precise constant frequency can be recorded, which upon playback may be used as a means for signal correction for the record and playback process, or the playback capstan drive speed may be corrected.

A frequency modulated signal requires a larger volume of tape than an amplitude modulation system since frequency modulation requires a higher range of frequencies and consequently a higher tape speed. For example, using the wide-band modulation just described, a signal range from zero to 1000 cps requires a carrier of 5000 cps, deviating between 2500 and 7500 cps for a maximum dc level. The burden of accuracy is transferred from the tape and pickup heads to the tape drive mechanism, but close tolerances and speed error compensation can yield accurate results.

To summarize, frequency modulation is a frequency-division type of system; it gives accurate data reproduction, has a high upper limit in frequency response compared to the time division methods to be described later, and is only limited at the low frequency end by dc drift. A further general limiting factor is the noise introduced by flutter and wow.

Multiplexing Systems

In order to allow the simultaneous recording of many information channels, various types of space and time sharing methods are currently employed.

Space-division may be defined as the storage of information on adjacent tracks. Multiple track recording as many as 25 tracks on a 2-inch wide tape is feasible. This technique may be combined with other methods for further increase of the number of recorded channels.

Frequency-division consists of a number of separate modulated sub-

CHICAGO
NOV. 14-17
1955

A New World
at your fingertips
as near as your date pad

—just flip the pages to November 14-17, and reserve those four days to explore new possibilities in applying the tools of automation to YOUR world of production.

The Second International Automation Exposition will open on November 14, 1955 at Chicago's famed Navy Pier. It will include:

FOR THE VISITOR —

- Computer and Automation application clinics and special related symposia.
- Exhibits of leading manufacturers displaying the latest developments in automation.

FOR THE EXHIBITOR —

- A show of proven merit for finding new and exciting markets, and expanding 'old' ones.

For complete exhibitor information, including a report on the success of the First Automation Show held last November in New York City, write to Richard Rimbach Associates at the address shown or use the coupon below.

SECOND INTERNATIONAL AUTOMATION EXPOSITION
859 Ridge Avenue, Pittsburgh 12, Pa.

☐ Send EXHIBITOR information.

☐ Send show visitor registration data.

Name ..... Title .....

Company .....

Address .....

City ..... Zone ..... State .....

carriers recorded on a single channel, similar to frequency modulated-to-frequency modulated and pulse width modulated-to-frequency modulated radio telemetering. In recording, the modulated subcarrier signals are combined in a mixing circuit containing suitable isolation. The composite mixed signal is then applied to the input of an audio type record amplifier. Alternatively, the composite signal can be used to modulate a wideband frequency modulated oscillator. Demodulation of the several information channels is accomplished by first separating the carriers in suitable band-pass filters and then detecting the signal in discriminator circuits. A particular disadvantage of this system of modulation is the poor signal-to-noise ratio which may be severely limited due to the narrow deviation ($\pm$7.5 per cent) of the subcarrier oscillators.

Now in time division, the information in the various channels is sampled in sequence by means of a switching device, either mechanical or electronic. The recorded signal consists of a series or group of pulses, each representing the magnitude of a signal channel at a particular instant of time.

Pulse Modulation

Several methods of time division are available.

1. Pulse - amplitude modulation, wherein the amplitude is proportional to magnitude of the represented signal
2. Pulse - time modulation, the time position of the pulse relative to a reference pulse is proportional to the magnitude of the signal
3. Pulse-code modulation, wherein the ratio of positive and negative rectangular pulses will contain the intelligence
4. Pulse - width modulation, the duration of a pulse proportional to the signal.
5. Pulse - code modulation, the magnitude of the data signal converted into a group of pulses representing a binary or similar code.

Two types, pulse-width modulation and pulse-code modulation are currently employed for tape recording.

Various methods of improving the quality of tape recording have been noted, including frequency and time-division methods. It has been pointed out that frequency modulation is intolerant to flutter and wow, and sensitive to drift in the electronics; pulse-width methods overcome these failings at the expense of limiting the frequency response. The systems which exhibit the least difficulties are those which employ pulse-code modulation, utilizing only two states of magnetization, *On* or *Off*.

By using binary pulse-code modulation, a high-quality signal can be obtained under conditions of noise and interference so bad that it is just possible to recognize the presence of each pulse. By suitable amplifying and reshaping, the initial signal-to-noise ratio can be maintained through a long chain. Pulse-code modulation offers no improvement in areas of high signal or low noise. Although such systems are somewhat more complex, they seem to be ideally suited for multiplex message circuits, where high standards of quality and relibility are required.

To improve the precision in frequency modulation by two to one requires roughly the same ratio of increase in frequency swing, hence requires greater bandwidth. In pulse-code modulation doubling the bandwidth permits twice the number of digits; therefore the number of distinguishable levels is squared rather than doubled.

A complete magnetic tape data recording system can be described, which uses pulse-code modulation. It consists of three units: an analog-to-digital converter and binary coder, a multitrack magnetic tape recorder, and a readout device. The converter processes the signal into an acceptable binary-digitized form. This is placed onto a magnetic tape recorder which provides a permanent, accurate record. Information can be recorded at high speeds and reproduced at lower speeds for later computation or printing out. Upon reproduction of the magnetic tape signals, the readout circuitry converts it to an acceptable form.

From a paper entitled, "Magnetic Tape Data Recording Systems" presented at the Summer and Pacific General Meeting of AIEE in June, 1954.

WE MUST AUTOMATE

W. R. G. BAKER
General Electric Co.
Syracuse, N. Y.

AS PROFESSIONAL engineers, we may attempt to discuss automation strictly as a long-range technical development. We may limit our discussion to feedback, to servomechanisms, hydraulics, pneumatics, hunting. We may attempt to reduce automation to an exact mathematical formula, but to no avail, for no matter how determinedly we attempt to do these things, our audience will evaluate what we say, not in technical terms, but in sociological terms. And even the engineer, I firmly believe, will find his thinking colored by the socioeconomic aspects of the subject.

Automation, in this regard, is somewhat like nuclear fission. As we well know from the public press, the nuclear scientists have not been able to remain uninfluenced by the possible uses of atomic energy, and have found themselves faced with the binding question whether their important work will be a boon to mankind, or the end of civilization.

Against what we are led to believe is the horrible historical example of the first industrial revolution, the engineer today may be undecided whether automation will result in mass unemployment, depression, bread lines and economic chaos, or a bright new world of higher incomes, shorter work weeks, more consumer goods and a general rise in the whole economic level of the peoples of the world. I would not blame the engineer who is confused for there has been much confusion, some of it created deliberately.

Our thinking has been conditioned falsely by some very vocal propagandists.

At this point I would like to quote two experts who say that we need fear a lack of sufficient employable persons, rather than technological unemployment.

The first expert is Mr. Ralph J. Cordiner, president of General Electric. In a talk last December, he said, "We must plan mechanization at an increasing rate if we are to meet the production demands that will be made upon us. Using

my own electrical manufacturing industry as an example, we know we must be able to double our production in the next 10 years. This is typical of the task facing all fast-growing industries. And yet we also know that the available work force will increase only 11 per cent by 1964. How are we going to accomplish this increase in production? The answer lies in increasing productivity at each stage of development in our operations."

The second expert I would like to quote is Peter F. Drucker, economist, consultant and author, who points out these facts in the March issue of *Harper's*. He estimates that in the next 20 years of our history, the total population of the United States will increase by at least two-fifths; population of working age will increase by less than one-third, labor force will go up by one-fifth and total hours worked by 10 per cent.

Mr. Drucker also states that technological advancement requires a tremendous increase in the number of trained and educated people and, "it is already true today that the short supply of such people is the major limiting factor on the rapid growth of our economy and our principal industries."

The real danger does not lie in automation, it lies in the actions of those who are too blind to see its benefits and who would slow down the wheels of progress by entangling them in inefficient make-work production methods.

If these reactionaries—the direct intellectual descendants of those who rioted against introduction of machine powered looms in England over a century ago—persist, they not only can slow down the wheels of progress, but they can endanger our national security and they could, if successful, reverse the whole process of technological advancement and start pushing the United States downhill in the direction of some of the backward nations of the world.

I would like to recommend as required reading, a talk given by Benjamin F. Fairless, chairman of the board of the United States Steel Corp., entitled "Our One Indispensable Weapon." Speaking of technological unemployment, he said, "So the time has come, I think, to nail this vicious propaganda for the miserable fraud that it is. The facts show that only through the widest possible use of new and better machines can we hope to achieve the fullest measure of employment and a higher standard of living."

To sum it up briefly, automation is nothing more nor less than providing of more efficient tools so that more people can have more goods at less cost. It cannot, by itself, do other than to help create an increasing demand for goods through placing those goods within reach of a larger proportion of the population of the world. It can raise our standard of living. It can make our nation stronger, better able to withstand the pressures and attacks of the totalitarian governments. It could be the strongest weapon in our battle to establish and maintain a free world for free people.

From a talk on automation delivered at the National Convention of IRE in New York, March, 1955.

THESE MEN DON'T GET PAID

BECAUSE THEY DO NOT EXIST!

When you engineer two and a half men off the production line (and more important, off the payroll) you are making real headway in getting your product cost down, no matter what you manufacture.

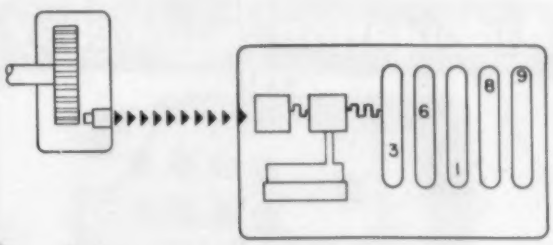
PEECO CUTS SMALL PARTS FEEDING PAYROLL 2½ TO 1

Peeco engineering helps you right in the payroll. They not only build better small parts feeders — they custom engineer the bowl to the part—and the 'payoff' is they work. Let Peeco help cut your production costs. Send for "Operation-Automation" today.

Small parts feeding is PEECO'S business—not a side line.

Peeco — PERRY EQUIPMENT & ENGINEERING CO.

3125 BRANDES ST., ERIE, PA.



For Accurate R.P.M. Measurement

Berkeley Industrial Tachometer

FEATURES—

- Accuracy ± 1 r.p.m. for any reading
- Range 0 to 100,000 r.p.m.
- Direct digital reading in r.p.m.
- Designed for production use
- Self-testing in 2 seconds
- Does not require mechanical connection to rotating part
- Printed record if desired

Complete application data on request; write for details.

M-28

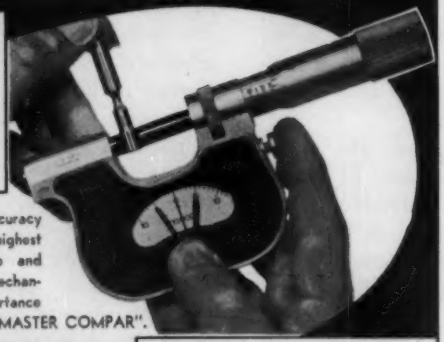
Berkeley *division*
BECKMAN INSTRUMENTS INC.

Dept. V7 2200 Wright Ave., Richmond, Calif.

The "MASTER COMPAR"

INDICATING MICROMETER COMPARATOR

has the VISIBLE feel



No Arguments as to correctness of reading due to "feel".
Use it as Comparator, Master Micrometer, Go & No Go Gage.
1" Range reading in 1/10,000"

To attain permanent accuracy at these close limits, highest precision workmanship and exclusive design of mechanism are of Major Importance and ONLY found in "MASTER COMPAR".

0-1" SIZE IN HARDWOOD CASE $95.00

Also Available in LARGER SIZES

A RIGHT HAND TOOL
Release button for movable Anvil on RIGHT Hand side enables you to hold tool the conventional way.

NEW—
Resetting to Zero in 5 seconds

Quick adjustable tolerance hands.

Heavy TUNGSTEN CARBIDE Anvils will actually measure Out-of-Roundness, Ovalness & Taper.

Ask for Illustrated Circular — Code GIOFF

Sold thru Tool Supply Houses

Ask for Demonstration

GEO. SCHERR CO., INC.
COMPLETE LINE OF PRECISION INSTRUMENTS
200-TO LAFAYETTE STREET • NEW YORK 12, N.Y.

Automation made easy

by a POTTER
PREDETERMINED COUNTER

Potter Predetermined Counters deliver precise control of any process which can be counted or measured. Exact, errorless quantity, length, revolution, time or sequence may be counted at speeds of up to 60,000/minute. Relay control is provided at the predetermined counts with automatic or manual reset. Electronic design precludes inertia. Maintenance is negligible. In single, dual or multiple sequence counters.

If you have a control problem we'd like to offer our recommendations—please write or call.

Potter
POTTER INSTRUMENT COMPANY, INC
115 Cutter Mill Road . Great Neck, N. Y.

AUTOMATION

new books

INDUSTRIAL AUTOMATIC CONTROLS

By Millard H. La Joy, associate professor of mechanical engineering, University of Minnesota; 278 pages, 5½ by 8⅜ inches, illustrated, clothbound, published by Prentice-Hall Inc., New York; available from AUTOMATION; *$6.65 postpaid.*

This book has been written as a beginning text in the study of industrial automatic controls. Two-position, proportional, floating (integral) and rate (derivative) modes of automatic control are discussed in separate chapters. Graphs depict characteristics, and examples are given of calculations to plot the graphs. Combinations of control effects are discussed as also are pneumatic, hydraulic, electric and electronic control circuits. A chapter of application examples includes the Instrument Society of America standard practice of identification, and symbols to be used in making instrumentation drawings.

FRONT LINE COST ADMINISTRATION

By Wilmer C. Cooling, manager, Methods and Standards Dept., International Resistance Co.; 259 pages, 5¼ by 8 inches, illustrated, clothbound, published by Conover-Mast Publications Inc., New York; available from AUTOMATION; *$5.00 postpaid.*

Foremen and supervisors are the "front line administrators" of all management policies which control manufacturing costs states the author. This book discusses and illustrates various techniques of industrial engineering which should be familiar to these administrators and many other people in management. Topics discussed include methods changes, production standards, wage incentives, indirect labor standards, product changes, job evaluations, reports, and training. Production standards and wage incentives are treated at greatest length because of their direct effect on costs.

Association Publication

PLANNING, MANAGING AND MEASURING THE BUSINESS

Paperbound, 63 pages, 6 by 9 inches; available from Controllership Foundation Inc., 1 East 42nd St., New York 17, N. Y.; $2.00.

Case study of management planning and control at General Electric Co. described by related reports of

six GE executives. The organization of the corporation, consisting of more than eighty businesses, is outlined. The line of production authority and responsibilities from product departments through product divisions and group executives in the president's office is sketched. Co-ordination of responsibilities with those of service divisions are also covered. The program is based on recognition of long term planning and control as a distinct function and responsibility of top management, and the organizational structure is specifically designed to be conducive to good long range consideration as well as short term planning and control.

Government Publications

Research in Nonlinear Mechanics as Applied to Servomechanisms. *Report* PB 111584 *by Wright Air Development Center;* 148 *pages, illustrated; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $3.75.

Application of nonlinear mechanics to the field of servomechanisms and the development of certain specific applications is described. Feasibility of dual mode operation is covered. Network synthesis procedures are applied to the synthesis of a continuous controller to replace the discontinuous controller used in the dual mode system. Development includes evaluation of germanium diodes as demodulators for servo work and determination of optimum size and shape of boundaries between outer and inner modes.

Application of Operations Research to Industry. *Report* PB 111596 *by Operations Research Office, Johns Hopkins University;* 62 *pages, illustrated; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $1.75.

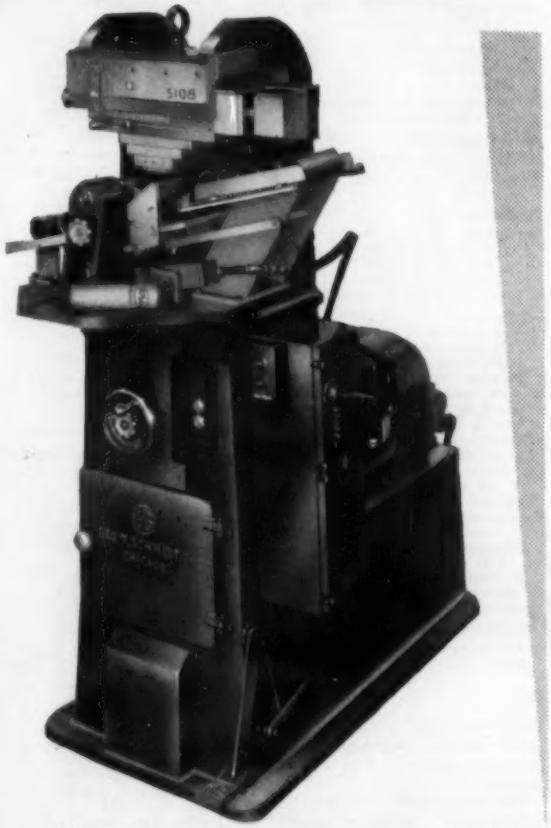
This 1955 edition describes functions of the operations analyst and his relations to the executive, the analytical tools used in operations research, and case histories. Techniques of scientific analysis, borrowed from military applications, are applied to industrial planning. Volume also includes a checklist for solving action problems, useful references, and a list of interested organizations.

Production Control Through Electronic Data Processing: A Case Study. *Report* PB 111580 *by Office of Naval Research;* 52 *pages; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $1.50.

Report considers some of the major principles involved in applying electronic data processing equipment to business operations. To illustrate application of these principles it describes an in-plant research study, made at a medium size manufacturing plant, and the data processing system which was prepared to meet production control requirements of this plant. Also included is a section on estimated costs, deliveries, and savings.

NOW AUTOMARKING

for faster, more uniform, less expensive identification of products and parts



The tube marker shown here, designed and built for a large automotive manufacturer, is a marvel of modern production efficiency. Tubes are given uniform and accurate identification, with a speed that lowers the cost-per-impression to a minimum.

2500 to 3000 Parts Per Hour

This JIC hydraulically-operated machine rolls a trademark and part number on mild steel thin walled tubes at a rate of 2500 to 3000 per hour, depending on length of marking.

Fully Automatic

A Geneva-type feeding mechanism receives parts from preceding operation and deposits them in a rotating spider. A retractable arbor supports parts during marking, after which spider carries them to discharge chute. Operation is *fully automatic.* Machine will not start marking cycle without work at station. Hydraulic action insures clean marking of uniform depth.

GTS engineers have designed many such Production Marking Machines for industry. They reduce marking costs to a fraction of those involved in old fashioned methods.

GTS sales engineers will be happy to call and confer with you on your specific problem.

IF IT'S WORTH MAKING, IT'S WORTH MARKING.

GEO. T. SCHMIDT, INC.
4108 Ravenswood Avenue
Chicago 13, Illinois

CUMULATIVE EDITORIAL INDEX

Including six issues. Number preceding the hyphen is month of issue; those following are page numbers in that issue.

A

Abbe, E. H.
Heavy Material Handling, 2-26
Accounting, 5-107
Administration, maintenance, 5-38
Aircraft, auto pilot, 3-66
Analog computers, 6-61
Analog systems, 5-55
Analysis,
of company for automation, 6-39
of elementary systems, 5-55
Annealing, 3-26
Appliance manufacture, 3-56
Assembly, 2-33; 4-65; 5-26; 6-14, 46; 7-48
Assorting, 5-68
Automatic control, 3-66
bibliography, 3-100
fundamentals, 4-37
merchandising, 3-110
terminology, 2-61; 3-37
Automation,
and engineers, 4-102
and labor, 6-120; 7-106
application of, 2-8; 6-30
benefits of, 4-26
definition of, 4-22
development of, 4-24
economics, 4-42; 5-28; 7-25
effects of, 7-25
evaluating for, 4-22
history, 4-24, 38
in the office, 2-65; 5-59, 107
partial, 4-23
philosophy, 2-117; 3-110; 6-116; 7-106
planning for, 3-41; 4-22; 5-30; 6-39
product design, 5-30
segmented, 6-13
survey, 3-41
Automobile manufacture, 2-8
Automotive parts manufactured, 2-62, 122; 5-29; 6-20

B

Band saw, 5-32
Batch process, proportioning, 3-17
Bearings, assembly, 4-36
Behrens, W. J.
Continuous Heat Treating, 3-26
Bibliography, automatic control, 3-100
Binary number system, 3-55
Blast furnace, charging control, 2-29
Block diagrams, 3-37
Bode diagram, 6-72
Boehm, W.
Conveyors Advance Rod Coil Handling, 6-52
Bolz, H. A.
More Effective Maintenance, 5-38
Bolz, R. W.
More Automatic Operation, 3-41
Stabilizing Factor, edit., 7-25
Boring gear blanks, 6-26
Bottling, 3-64
Box making, 2-123
Broadcasting, automatic, 4-14
Brown, J. J.
A Functional Morphology of Mechanisms, 7-37
Bulk handling, dry materials, 6-35
Business machines, 2-69; 5-59

C

Camera, automatic, 5-12
Can opener manufacture, 6-49
Capacitors, electronic, 2-127
Capital, expenditures for automation, 6-44
Carbon dioxide, shielded arc welding, 7-10
Cards, punched, 2-65; 5-64
Carney, E. A.
Small Parts Handling Can Be Critical, 7-57
Carton manufacture, 6-16
Cement product mixing, 2-59
Chart identification, 4-12
Circuits,
printed, 3-14
rectifiers, 4-110
television, 2-31
transistor, 4-110
Classification of mechanisms, theoretical, 7-37
Classifying-gears, 4-47
Cleaning, metal, 3-55
Closed-loop control, 4-40
Coal,
handling, 2-26
mining, 2-46
Coatings, applications, 4-77
Codes, telemetering, 6-110
Coding, information, 4-100; 6-110
Coffee bean sorting, 2-74
Coil handling, 6-52
Coin collection, 5-12
Collet, pneumatic, 3-15
Color sorting, 2-74; 5-99
Common language tapes, 2-65; 5-59; 7-53
Communications, 5-97; 6-126
telemetering, 5-46
Complex servos, 3-65
Computers, 2-10; 5-97, 107; 6-126
analog mechanical, 6-61
digital, 2-12; 4-104
Computing mechanisms, 6-61
Conductance, gaging, 6-57
Contents, 7-3
Control,
aircraft, 2-114; 3-16
analysis of systems, 5-55
blast furnace charging, 2-29
derivative, 7-69
electrical, 2-28, 122; 3-36, 40; 4-76; 5-65; 7-35
electronics, 2-12; 3-62; 4-76
engine fuel, 2-122
furnaces, 3-32
hydraulic, 3-36; 4-56
ingot soaking pits, 2-10
instrument, 3-106
integral, 7-64
liquid level, 4-56
machine, 2-10
machine tool, 4-76
modulating, 7-63
motor, 2-126
multispeed floating, 7-65
nozzle, 2-114
open-loop, 4-38
paper sensitizing, 4-9
photoelectric, 3-62
pressure, 4-98
process, 3-66
proportional, 7-63
proportional plus derivative, 7-69
proportional plus derivative and integral, 7-70
proportional plus integral, 7-67
proportional speed floating, 7-65
remote, 5-32
rate, 7-69
reset, 7-65
rinse tank, 4-9
single speed floating, 7-65
stream flow, 6-12
system designs, 6-65; 7-108
system response, 5-55
tape, 3-62
temperature, 2-114
terminology, 2-61; 3-37
two-position, 7-61
Controllers
action, 7-108
process, 3-66
timing, 6-15
uses and characteristics, 7-60
Converters, signal to digital, 4-10
Conveying, 3-64; 5-68; 6-35; 7-31
Conveyors, 2-14, 126; 3-106; 4-76; 5-13, 97
belt, 2-26, 46, 122; 4-76; 5-68
chain, 3-26; 6-52
chip, 3-33
coal, 2-26
drag, 6-52
idler, 2-122
ore, 2-26
overhead rail, 3-18
overhead screw, 2-73
paint, 5-66
pneumatic, 3-18; 6-35
pump, 3-16
slat, 2-122; 3-26; 6-52
Cost administration, 7-108
Crane scales, 7-26
Crankshaft manufacture, 2-62; 3-58
Cutoff machine, 4-33
glass, 5-33

D

Data processing, 2-65, 122; 3-18, 55; 4-76, 100, 104; 5-16, 46, 59, 97, 118; 6-76, 126; 7-53, 92, 109
Dermitron, 6-57
Design, for assembly, 7-48
Differential computer, 6-61
Digital computers, 2-12; 4-104
Dimensioning, 5-118
Direction finder, 5-13
Disconnect, explosive, 4-14
Distribution: See Warehousing
Downtime, 7-31
Drum, memory, 3-55; 6-76

E

Economics, 5-28; 6-43; 7-25
Education, 4-21
Electrical,
connector manufacturer, 6-50
control, 3-36, 40; 4-76; 6-30; 7-35
maintenance, 5-18
rectifiers, 4-110
Electronics, 6-126
control, 2-12; 3-62; 4-76; 5-18
transistor circuits, 4-110
tube specifications, 5-118
weighing, 5-110
Electroplating, 5-37, 99
Electrostatic generator, 7-92
Employment, 3-101; 5-25; 6-126
Engine, aircraft, 2-122
Engine manufacturing, automobile, 6-20
Engineering,
of assembly machines, 7-48
organization, 2-35
systems, 2-35; 3-49; 4-58
Engineers and automation, 4-102
Escapement, 7-50
Evaluating for automation, 4-22
Evacuating glass blubs, 4-34
Evanson, C. E.
Analyses for Automation Planning, 6-39
Evaluating and Planning for Automation, 4-22
Extruding, plastic, 7-31
Extrusion dies, 5-32

F

Fastener, Special rubber, 7-9
Fastening, screw-automatic, 7-10
Feedback,
control system, 4-40; 6-126
control, testing, 3-98
servos, 3-65
Feeders, 4-10
pneumatic, 3-15
Feeding, 7-35, 50
Filing, punched tape, 2-72
Filling machine, 5-36
control, statistical, 7-42
Filling method, 6-102
Film control, processing, 3-16
Finishing, metal, 3-56
Fixture,
magnetic, 3-15
shuttle, 6-18
Forging, 3-58
heat treating of, 3-26
Forms, paperwork, 2-67
Foundry, automation, 7-73
Frequency modulation, 7-105
Frequency response, 6-65
testing, 3-98
Furnaces, 3-58
heat treat, 3-26
pipe mill, 4-32
Fusing glass bulbs, 4-34

G

Gaging, 2-123; 6-102
air, 6-28
balls, 7-52
bores, 6-26
continuous, 3-40
for process control, 2-42
plating thickness, 6-57
pushrods, 2-42
radiation, 2-123
wrist pins, 2-42
Garrott, P. B.
Automation in Paperwork, 2-65
Tying Paperwork to Production, 7-53
Gear boring and gaging, 6-26
shaving and gaging, 4-47
General purpose machine, 5-30
Gittens, E. D.
Management of Systems Engineering, 2-35; 3-49; 4-58
Glass bulb evacuating, fusing, 4-34
Glass forming, 5-33
Globe valve manufacture, 5-30
Grinding, 2-62; 7-93
Gunnery, 3-66
Gyro, 2-16; 3-66

H

Hadekel, R.
Hydraulic and Pneumatic Servos, 2-49; 3-65
Handling, 7-92
bulk, 6-35
coal, 2-26
conveying, 2-26, 46, 73, 122; 3-26, 58; 4-54, 76; 5-66, 68, 97; 6-102; 7-100
data, 2-65
feeding, 2-62; 3-58, 106; 7-50
ore, 2-26
pallet, 3-64
rod coil, 6-52
shake-out, 6-102
small parts, 7-57
sorting, 2-74; 7-50, 52
Hardening, 3-26
Hardness testing, 2-44
Hardware,
handling, 7-57
manufacture, 5-29
Harvey, A.
Warehousing and Assorting System, 5-68
Heat processing, 3-102
Heat treating, 3-26; 4-54
Home appliance manufacture, 3-56
Host, J. A.
Automatic Assembly, 5-26; 6-46; 7-48
Humidification systems, 2-20
Hydraulics,
control, 3-36; 4-56
presses, 3-14; 4-56
servos, 2-8, 49; 3-65
systems, 2-115

I

Indexing, 4-100; 7-46
Information, searching, 3-18; 4-100
Infrared analysis, 6-12
Inspection, 4-8; 6-41
automatic, 3-40
Instruments,
control, 3-106
recording, 2-122; 4-10
scale, 5-16
Integrated data processing, 2-65; 5-59; 7-53
Integrating computer, 6-61
Inventions, 4-43
Inventory control, 5-107
Inverter, case, 4-76

K

Kendall, G. H.
Automatic Assembly, 5-26; 6-46; 7-48

L

Labor, 3-105; 6-42, 120; 7-106
Law, patent, 4-43
Leaver, E. W.
A Functional Morphology of Mechanisms, 7-37
Lemon sorting, 2-74
Light source controlled, 6-15
Liquid level,
measuring and telemetering, 5-46
Liquid sensing, 7-10